PROBLEMS OF WAR AND OF RECONSTRUCTION

EDITED BY

FRANCIS G. WICKWARE

THE AMERICAN AIR SERVICE

AMERICAN AIRPLANE PHOTOGRAPH OF THE VILLAGE OF CANTIGNY DURING THE SUCCESSFUL ATTACK BY AMERICAN TROOPS ON MAY 28, 1918. TAKEN AT A HEIGHT OF 700 METRES

PROBLEMS OF WAR AND OF RECONSTRUCTION

THE AMERICAN AIR SERVICE

A RECORD OF ITS PROBLEMS, ITS DIFFICULTIES, ITS FAILURES, AND ITS FINAL ACHIEVEMENTS

BY

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WITH AN INTRODUCTION BY

NEWTON D. BAKER

SECRETARY OF WAR

ILLUSTRATED

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TO
MY WIFE

THE AUTHOR'S ROYALTIES
ON THE SALES OF THIS
VOLUME ARE DEVOTED TO
THE AMERICAN RED CROSS

PREFACE

The Air Service has been almost universally misunderstood, even among its friends. It has been so wholly new and so firing to the imagination, its development has been so enshrouded in secrecy on the one hand, and so emblazoned by misrepresentation on the other, that even men actually officers of its staff are bewildered and confused as to the actual facts. It is doubtful that so little of the truth was ever known about an enterprise of such surpassing national importance.

The story of the Air Service is a story of contrasts running from high lights into the deepest shadows. Initiated in a burst of enthusiasm and imagination almost unparalleled in our history, driven along the road towards accomplishment with skill and energy but without the supergenius that alone could have brought success, set upon at the most unfavorable moment by an outburst of public disappointment, yet finally crowned with a superb record over the lines in Belgium, France, and Italy, it is a story that well deserves to be understood.

It has had its failures, serious failures indeed, but it has also had its successes. We have heard very much of the former and very little of the latter. The story of how an unprecedented programme was adopted and carried out, of teaching men to fly, to use machine guns, cameras, and bombs in the air, of developing new industries and converting virgin forests into airplane wings and fuselages, of erecting airdromes and factories in England and France, and finally of meeting the enemy fliers over No Man's

Land — all this forms a stupendous picture that deserves to be put into a permanent setting.

America dedicated herself to the conquest of the air. She failed in the time allotted because she had utterly no knowledge of the myriad difficulties that confronted her. This does not mean, however, that her effort was not supremely worth while and that by it she did not accomplish infinitely more than if she had aimed less high. America's Air Service at the termination of hostilities had a personnel of over 150,000 men, more than half of them in France, over a thousand trained fliers on the front, a system of schools here, in France, and in England capable of an expansion that would soon have been overwhelming to the enemy, an industrial machinery which, with its Liberty Motors, De Haviland planes, raw materials, and accessories was fast becoming the Allies' supply center, and above all a record of 845 enemy planes driven to destruction.

It is my hope that this book may throw these main outlines into their true perspective. Every cable, letter, document, and chart desired has been available in its preparation. Out of all the overwhelming mass of detail, I have endeavored to select the highlights of historical importance, so as to provide new information for those already familiar with parts of the subject, while not confusing those unfamiliar with it in a maze of detail. If at times there is a surfeit of facts and figures, forbearance is asked in recognition of the fact that years may pass before another writer has the time to go over this ground again, and that consequently it is better to include too much than too little. A very conscious effort has been made throughout to let the facts and figures speak for themselves without prejudice of the writer's personal opinion.

PREFACE

American aviators have been stated by their Commander-in-Chief to be without equals in daring or fighting ability. It is fitting that the great organization of which they form the apex should be worthy of the traditions they have set. If this book serves to bring about a fairer and more complete judgment of the whole situation, if it explains the romance and achievements as well as the difficulties and failures of the aviation project, I shall feel that it has been worth while.

I desire here to express my deepest appreciation to three collaborators without whose aid the publication of this book in the present circumstances would not have been possible. As it happened, just after the manuscript had been finished, the author was called to Europe for work in connection with the Peace Conference and was constrained to leave to others the work of proofreading and the extremely complicated task of checking the great number of figures in the book.

To his wife, to Captain E. H. Cumpston, Statistical Officer of the Air Service, and to Mr. Francis G. Wickware, the editor of this series, he is most profoundly grateful.

ARTHUR SWEETSER.

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INTRODUCTION

In these pages Captain Sweetser has told in a vigorous and comprehensive way the story of the American Air Service. Happily, he begins with the story of Samuel Pierpont Langley, who, after years of patient study, first achieved actual flight by a heavier-than-air machine and must always be regarded as the discoverer of the principles which made the spectacular triumph of later years possible. Professor Langley was a great scientist; his life had been spent in high and useful pursuits; but throughout all his later years he followed the lure of the idea which he had caught from the birds, and his daring imagination refused to be trammeled by demonstrations which other eminent scientists made by mathematical processes of the impossibility of mechanical flight. When he died, his full-scale demonstration had been wrecked by trifling accidents. The doubters had all their own way, and he was saved from ridicule only by the eminence of his scientific reputation and his known services in other fields of human knowledge. But the very machine which trickily failed to fly for him subsequently flew, and it is now preserved in the Smithsonian Institution, over which Professor Langley long presided, and for all time will be the vindication of Langley's claim.

The application of the principles thus discovered and demonstrated came from other hands. The story is here unfolded in detail. Reading it, we realize that we of this generation have witnessed the genesis of an idea which may prove as revolu-

tionary as the steam engine, and which has already so far developed as to transform the whole art of war. Professor Langley's first flight was in 1894. In 1903 the larger demonstration was attempted. In the same year the Wright brothers actually flew their first machine at Kitty Hawk. Fourteen years later the horsemen of the air charged through the clouds on every battle front, directing artillery fire, bombing rear areas, and engaging in hand-to-hand conflict with one another at dizzy heights in the very vault of the heavens.

Especial interest will attach just now to the chapters of this book that deal with the initiation and development of the American aircraft programme for the European War. At the outset of our participation it was believed by those who had most seriously studied the subject to be impossible to organize, equip, and transport to France an American army of such a size as would materially affect the numerical balance between the enemy and the Allies. The French and British Missions which visited us, having in mind the size of armies hitherto transported great distances by sea, urged only the sending of a modest force in order that the American flag might appear with those of the Allies and America's participation be made palpable by the presence of American soldiers on the Western Front. No such vast American army as was subsequently organized and transported was deemed either necessary or possible. It was for this reason that the suggestion of the French Prime Minister, that we embark upon a great aviation programme, was favorably received. The programme as cabled to us from France called upon America to do in one year more than twice as much as France was then doing at the end of substantially three years of war

pressure, and this we were to undertake in an industry which had been neglected among us and in which the progress made abroad during the war had been largely withheld from us. Probably no military secrets were more closely guarded in Europe than developments in aircraft. As a consequence, when we entered the war, airplane construction in the United States was upon a most limited scale, and our knowledge of the developments which had taken place in Europe was largely hearsay. It did seem to us, however, that in view of the fact that we could not overcome transportation limitations enough to send a great army, we could mobilize the machine-trained industry of America and make our contribution to the Allied cause complete and unquestioned mastery of the air.

The response of both Congress and the country to this suggestion was immediate and enthusiastic, and with generous appropriations the work was undertaken with an enthusiasm which refused to see the difficulties or to be chilled by delays and embarrassments however exasperating. As the aircraft programme moved along, it became apparent that it was not to be America's sole, or even her greatest, contribution to the cause. Our national energy was not limited to this development, but became involved in an industrial and military mobilization which left us at the signing of the armistice with an army of two million men in France and substantially another two million in training and in service at home. We developed through the Chemical Warfare Service the introduction and production of new gases, enormously increased the output of small arms and ammunition, devised new machine guns and automatic rifles, and did a thousand other things on a great scale. Meanwhile, with men of the highest

talent and devotion, called from civil life, the aircraft programme was developing, its delays and difficulties were being overcome, and sober experience was forcing limitations of time which enthusiasm and zeal had refused to recognize. As I have read Captain Sweetser's manuscript, it has seemed to me that he tells candidly and fully the difficulties and also the achievements. The record he gives is substantially that contained in the official proceedings of the War Department, and I have no doubt that those who have been most immediately responsible for the work in aircraft will desire no other judgment passed upon them than that which justice deduces from the facts.

After all is said, the great mistake in the air programme was publicity. This was pointed out by Mr. Mann on the floor of the House of Representatives in a very sane and wise speech. If there had been no publicity on this subject, the work done on the air programme would have seemed a very great achievement. Its misfortune is that it fell short of the hopes of its authors and keenly disappointed the imagination of the country, which had been aroused to great expectations. We were dealing with a miracle. The airplane itself was too wonderful and new, too positive a denial of previous experience, to brook the application of any prudential restraints which wise people would have known how to apply to ordinary industrial and military developments. As a consequence, the magicians of American industry were expected to do the impossible for this new and magical agency, and this expectation was increased by the feverish earnestness with which all Americans desired that our country should appear speedily, worthily, and decisively in the war. Whether so large a programme

could have been accepted by the Congress and the country without some such advertisement, no one can now say; but in view of the very understanding debate in Congress, it seems likely that it could, and further likely that the expectations ultimately defeated were rather those of the public imagination than of the sober statesmen who voted for the programme and understood better than was possible for the general public the difficulties and discouragements likely to be encountered.

No doubt a just appraisement of America's effort in the air will soon be made. The history of this war will be written and the separate services will have their accounting. When that is done, it will be well if we learn from our experience with the air programme to avoid too rosy-colored expectations, while we at the same time preserve that necessary enthusiasm and determination without which great enterprises are impossible. The history of the Air Service will show the development and production of the Liberty Motor as a great achievement; it will show the fertility and ingenuity of the American engineer and the capacity of American business for hasty and large-scale organization. The pages of that history, too, will be replete with stories of adequacy on the part of American men under the supreme tests of this newest mode of warfare. The age of Elizabeth is famous for her "sea dogs." This age, for America, will be famous for our soaring soldiers who showed an aptitude for learning this game and a bravery in playing it which reflect great glory on the race from which they spring.

Perhaps, however, the greatest value of this book will lie in the fact that it is an authoritative statement of the present state of the conquest of the air. The necessities of war speeded the development of

aircraft enormously. Ten times as many years would not have produced the same advance if the years had been devoted to peaceful pursuits and commercial uses of airplanes had been the only incentive to inventors and producers. With the start now made, however, it is difficult to restrain one's forecast of the possibilities of the immediate future. Long-distance flights and high altitudes have become commonplace; that the Atlantic will be successfully crossed by airplane seems not only possible, but certain, and that in all likelihood within a few months. Elaborate plans are making in all countries for aerial postal service; and with the perfection of appliances new possibilities of use will be discovered, until the airplane upon its mission of peaceful commerce or service will be as familiar to the next generation as the locomotive is to this.

In the meantime, apparently unlimited possibilities of development have opened for lighter-than-air devices. The old balloon which followed the wayward currents of the air has been replaced by motor-driven dirigibles; and now we have the commercial production of helium to replace hydrogen, thus removing the hazard of inflammability which has hitherto not only made ballooning perilous, but limited the engineering possibilities in balloon construction.

The imagination leaps at the possibilities of these developments. We cannot foresee or foretell what services these new wonders are to render to mankind. The possibilities are limitless; but as yet we can only stand by the wayside and exclaim as they go by: "My father, my father, the chariots of Israel and the horsemen thereof!"

NEWTON D. BAKER.

THE AMERICAN AIR SERVICE

CHAPTER I

THE BIRTH OF AMERICAN AVIATION

Langley's aerodrome — Its scientific success, its tragic failure, and its final vindication — Early experiments of the brothers Wright — Their first flights — Interest of the War Department awakened — The first Government specifications for aircraft — Official demonstration of the conquest of the air — Birth of Army aeronautics — Apathy of Congress — Foreign military developments — First Congressional appropriation — Establishment of the first Army flying school — American airplanes in military operations — The first military planes — Transfer of the Army training school to San Diego — Low state of American aviation in 1913 — Unpopularity of the service in the Army — The Aviation Section created in the Signal Corps on the eve of the European War.

Aviation in the United States opened with one of the hardest fought and most thrilling battles in the history of science, a battle the almost startling success of which was wholly negatived by a tragedy of misunderstanding. The story of Professor Samuel Pierpont Langley and "Langley's Folly" shows as few others can the marvelous overcoming, one after another, of almost insuperable obstacles through the cold, logical working of a master mind threading its way through a scientific wilderness. At the end came tragedy, for just as success was about to be attained, a burst of ridicule flared out and the age-long ambition to fly had to be left unfulfilled by the first discoverer of the physical means.

Langley's interest in flight dated back, as with so many others, to the days when, as a boy, he had lain in the pastures and watched the birds soaring over-

head. In 1886, when his mind had become highly trained in science, he was roused to an active study which was destined to lead him through 18 years of the most arduous, time-denying, and almost impossible work. There was no place to begin other than at the beginning, so Langley started out to discover the principles of flight by all manner of primitive arrangements, such as rubber-driven models and a huge revolving table with arms sweeping through a 200-foot circumference at a speed of 70 miles an hour. After three tedious years he satisfied himself that flight was possible because of the sustaining power of the air, and on the principle that "a swift skater runs safely over the thin ice or a skipping stone goes over water without sinking, until its speed is exhausted."

In 1889 began the application of these principles to an actual model, or "aerodrome," as he called it, from the Greek equivalent of "air runner." This was a small machine, not big enough to carry a passenger, but sustaining itself entirely by an almost human perfection of balance. "Everything," Langley wrote, "not only the engine but the boilers which were to supply it, the furnaces which were to heat it, the propellers which were to advance it, the hull which was to hold all these — were all things to be originated in a construction which so far as I knew had never yet been undertaken by anyone." Four more years were consumed in this work. Finally, on May 6, 1894, after innumerable delays, "for the first time," as Langley wrote, "the aerodrome swept continuously through the air as a living thing, and as second after second passed on the face of a stop watch until a minute had gone by and it still flew on, and as I heard

the cheering of the few spectators, I felt that something had been accomplished at last, for never in any part of the world or in any period had any machine of man's construction sustained itself in the air before for even half this brief time."

Langley now regarded his work as completed, but the Government at once investigated his achievement and directed him on November 9, 1898, to attempt to adapt the principles he had discovered to a man-carrying machine for use in warfare. In this investigation a new series of delays and disappointments met him at every turn, notably the total lack of an engine of suitable lightness and power, which sent Langley on a fruitless search throughout Europe, with the final necessity of adding this new problem to his own difficulties.

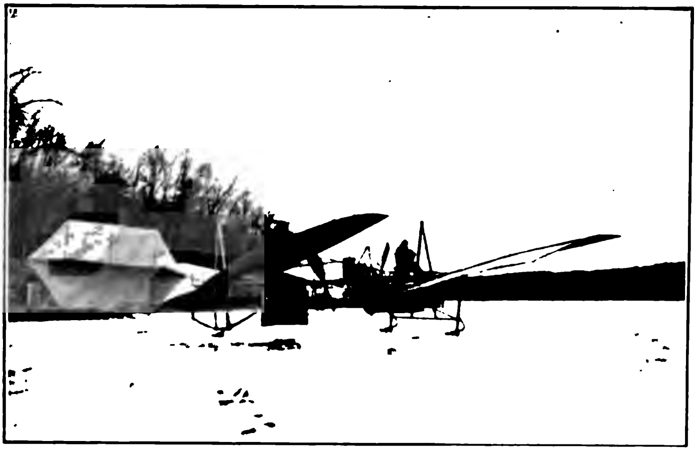
On August 8, 1903, on a malarial section of the Potomac 30 miles outside Washington, a small model was successfully launched by being driven along a runway on top of a large houseboat in order to gather momentum before taking the air over the water. Tragedy lurked close at hand, however, for when, on October 7, the first man-carrying machine was launched, it was caught by the falling ways and pulled head-on into the river. Nothing could have been more fatal. The great number of newspapermen, practically all feature writers rather than technical experts, who had spent many weary days in the malarial, uninhabited country nearby and who had been greatly provoked by Langley's silence, burst into sarcasm and ridicule which left practically no opportunity for impartial judgment. A subsequent failure from the same cause, which nearly resulted in

the drowning of the engineer and increased the ridicule of the press, discouraged the War Department from any further efforts.

Nevertheless, let it be said, Langley's vindication has since come, although he himself did not live to see it, succumbing three years after the tragedy to what many called a broken heart. On April 2, 1914, the old, original machine, which had never been given a fair test, was shipped to Hammondsport, New York, where on May 28, equipped with pontoons but otherwise practically unchanged, it rose from the water and sailed through the air as gracefully as any of the great
6 modern planes from the big Curtiss factory nearby.

Very different from Langley's methods were those adopted by Orville and Wilbur Wright in their efforts to solve the age-long problem of flight. Unlike Langley, the scientist and theoretical thinker, they approached the problem from the experimental point of view, as accorded with their experience as manufacturers of bicycles.

In 1899 the two brothers first came to an interest in flight through observation of birds and study of books on ornithology. Unsuccessful in their first attempts to secure books on aviation, they later acquired an appreciable library on the tragic failures of others who had attempted to conquer the air. They presently convinced themselves that all of these efforts had come to naught, not so much because of faulty plane design or engines, but rather from lack of knowledge of the principles of equilibrium. So in 1900, along the soft sandy stretches at Kitty Hawk, North Carolina, away from fugitive air currents and land obstructions, they began a series of experiments



LANGLEY'S AIRPLANE WITH THE ORIGINAL MOTOR ON THE ICE AT HAMMONDSPORT, 1914

THE ORIGINAL WRIGHT MACHINE IN ITS FIRST FLIGHT AT KITTY HAWK, DECEMBER 17, 1903

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with gliders which embraced the new principles, adapted from the birds, of a warping wing to insure balance. Although this was their first contribution to practical aviation, the success achieved appeared to them so small that Wilbur wrote, on their return to Dayton, that it was extremely doubtful if "we would ever resume our operations."

The fascination of it, however, had entered too deep. "After our return home," again to quote Wilbur, "we could not keep our minds off the puzzling thing we had observed, nor keep from studying possible solutions of our difficulties, and before long we were as deeply interested as before." In 1902, they again went to Kitty Hawk, installing this time the innovation of a fixed vertical vane at the rear of the glider, which worked, Wilbur wrote, "as we had expected, so that we could control lateral balance or steer to the right or left by the manipulation of the wing tips." Over 70 glides, some 600 feet in length, were made, with or against the wind, and under good control.

Next came the adaptation to a motor-driven plane. During the fall of 1903 a most primitive machine with a 12 horse-power, 200-pound gas motor was put together at Kitty Hawk, the construction requiring the operator to lie prone and control the front horizontal rudder with his hands and the vertical tail by a cradle in which his hips rested. On December 17, 1903, Wilbur Wright rose into the air for the first time that man had ever flown in a mechanically driven, heavier-than-air machine. Four short flights were made; the first was barely skips, but the last covered 850 feet in a time of 59 seconds. During

the summer and autumn of 1904, a second machine was built, and on September 20 the first circular flight ever made took place. During the year 1904 the Wrights went up over 100 times, and in 1905 they reached a record of 24 miles in 38 minutes.

By this time the secrecy with which the Wrights had surrounded their early work had been gradually dispelled, and the world began to knock insistently at their doors. In 1907 they offered to sell all their rights and interests to the United States Government, but the Board of Ordnance and Fortification replied rather tersely that it had no money available for the purpose. Nevertheless, the War Department was awakened to the possible military value of aircraft and on December 23, 1907, issued the first airplane specifications ever drawn by a Government body. Strikingly enough, these specifications were largely drawn by Major George O. Squier, who later was to be charged with the greatest aeronautical expansion ever attempted. They were made especially severe, requiring a speed of 40 miles an hour, a flight of an hour with two persons of a total weight of 350 pounds, fuel-carrying capacity sufficient for a flight of 125 miles, and ability to steer in all directions without difficulty. Twenty-four bids were received, but only two contracts were awarded, that of the Wrights being dated February 23, 1908. Congress refused utterly to countenance this work, denying the $200,000 appropriation asked through the Secretary of War, and necessitating recourse to the Board of Ordnance and Fortification for funds.

In September of 1908 came the tests the world was waiting for, the tests that were to demonstrate pub-

licly and on the authority of the Government that the conquest of the air had been achieved. On the ninth day of that month, on the parade ground at Fort Myer, just outside Washington, Orville Wright moved his odd-looking mechanism out of the shed at 7:50 a. m., and with only a little effort rose gracefully and easily into the air. Fifty-seven times he circled the grounds at a height of about 100 feet in a time just short of an hour. That afternoon he made the first flight of over an hour, completing 55 rounds in one hour, two minutes, and 15 seconds, and later he took Lieutenant Lahm as passenger for a trip of six minutes and 24 seconds.

Flight was now publicly demonstrated. Nevertheless, so great was the interest and enthusiasm that Orville continued his exhibits, taking Major Squier up as a passenger on September 12. Then on September 17 came the first fatal accident; the propeller blade broke when the machine was at a height of about 75 feet, the plane careened, glided 35 feet, and then pitched forward to the ground, killing Lieutenant Selfridge and injuring Wright. This, America's first sacrifice to the science of aviation, put an end to the experiments for the season, although Wilbur Wright in France continued to electrify the scientists of Europe.

In July, 1909, the Wrights returned to Fort Myer with a new plane which not only was accepted by the Government under the original agreement, but earned an additional $5,000 bonus for the inventors by a successful 10-mile cross-country flight. Now for the first time the United States Government possessed a man-carrying airplane, and with the aid of the

Wright brothers, although still without Congressional appropriation of funds, the first steps in teaching Army aviators to fly were taken.

Progress during the next few years was amazingly slow when looked at in retrospect. The difficulties that aviation had in securing a foothold, even when proved, are surprising. The War Department's annual reports were as voices crying in a wilderness, without echo or response. In the year of the Wrights' first flight, General Allen, the Chief Signal Officer, made what one would expect to have been a startling statement, that "the age of mechanical flight is at hand." In 1909 he reported that the Wrights had flown for two hours and 20 minutes, had carried a passenger one hour and 20 minutes, and had reached a height of 400 feet, while six aviators had crossed the hour mark and flights had been made across the English Channel and from Governor's Island to Grant's Tomb in New York City and back. "All first-class powers except the United States," he said, "are providing themselves systematically with aerial fleets."

The year 1910 General Allen reported as one of "unprecedented activity." Speed had increased over 50 per cent. to above a mile a minute; the non-stop flight record had gone up to 244 miles in five hours and 32 minutes, the altitude record to 8,692 feet, and the horse power of motors from 25-30 to 50-100; while the Alps had been crossed in 40 minutes, flights made from Paris to London, and four passengers carried beside the pilot. The United States, however, "had been left far behind," having but one lieutenant and nine enlisted men on aeronautical duty. The science

must be considered, he said, "whether we wish to or not." His recommendation is noteworthy, dating back as it does hardly beyond yesterday to the year 1910. "At a low estimate, it is believed that at least 20 aeroplanes should be in the service of the United States. . . . This estimate is considered extremely low." Nevertheless it failed of acceptance.

Meanwhile France and other European nations were developing what the United States had invented. At the French Army manœuvres on September 9, 1910, an officer made four reconnaissances in quick succession. On one of these trips he discovered that a counterattack was in preparation on the right flank. He flew quickly to the nearest brigade headquarters, secured a horse, and galloping to the general, gave him the information which enabled timely preparations to ward off the blow.

All this evidence, however, with the increased public interest through a series of exhibition flights all over the country, was having weight with Congress. March 3, 1911, deserves to be marked as a red-letter day in American aviation history, for on that day the first appropriation ever allotted to aviation by the law-making body was enacted in the Army Appropriation Act for the fiscal year 1912. Thus, three years after the Wrights had officially demonstrated the fact of flight, when aviators were in the air all over the world, and when France was asking for $1,000,000 for aviation, the new science was formally recognized in the United States with an appropriation of $125,000.

A real beginning in Government aviation was thus made possible. Planes were purchased to train offi-

cers at San Antonio, Texas, and to participate in actual field reconnaissance there. In June, 1911, the first real flying school was established at College Park, near Washington, and by the end of the year America boasted five planes, three balloons, and six licensed pilots. During this first pioneer year, nine officers made 731 flights for a total time in the air of 129 hours and 39 minutes, with but one fatal accident, that of G. E. M. Kelly, for whom Kelly Field was later named. It is interesting to note that the high record was made by Lieutenant B. D. Foulois, later American Air Service commander-in-chief in France, with 312 flights for 52 hours; and the second highest record by Lieutenant H. H. Arnold, later Assistant Director of the Division of Military Aeronautics, with 140 flights for a total of 29 hours. Lieutenant Arnold also was the first Army aviator to fly over an hour, being in the air one hour and two minutes at College Park on August 21, 1911, with a distance of 42 miles. The general progress of aviation during the year was described by General Allen as "without precedent." Speed increased to 80 miles an hour; distance to 400 miles, including cross-country flights from St. Louis to New York *via* Chicago; the length of time in the air to 14 hours; altitude to 13,000 feet; and the number of passengers to 12. The hydroplane had been developed, and mails carried both in this country and in England.

The year 1912 saw a similar extension. In August came the Army manœuvres at Bridgeport, Connecticut, where four aviators, with two very old and out-of-date single-seaters, located troops and plotted terrain at 2,500 feet, made photographs at 1,500 feet, and

FRONT OF THE FIRST AMERICAN "LIBERTY" CAPRONI

FRONT OF THE AMERICAN HANDLEY-PAGE, SHOWING SECRETARY OF WAR BAKER AND GENERAL MARCH, CHIEF OF STAFF

signalled by radio for 12 miles. Airplanes were used for the first time in the United States in connection with artillery fire from November 5 to 13, 1912, at College Park. Three methods of signalling were used to control the batteries — radio, dropping of cards, and smoke signals, and the airplanes established their value for this work beyond dispute. Also the first known use of machine guns from airplanes occurred at College Park at this time, an Army aviator demonstrating the possibility of offensive aerial warfare by securing 14 hits out of 50 shots on a cloth target 60 feet long by five feet wide when travelling at a 45-mile speed.

College Park by November 1, 1912, had grown to have 12 officers, 39 men, 12 planes, and eight hangars, virtually the Government's entire aeronautical capital. During the year the first so-called "military planes" were received, the speed-scout single-seater type having a radius of 100 miles at a speed of 65 miles an hour, and the two-seater scout with 45 miles an hour speed, three hours' flight endurance, and weight-carrying capacity of 450 pounds. All machines previously used had been ordinary commercial planes sufficient for exhibition flying but lacking the power, speed and carrying capacity necessary for military use. Just two less than 1,500 flights were made in the fiscal year 1912, by 14 different fliers for a total time in the air of 224 hours and 55 minutes. Lieutenant Milling made the high record with 431 flights, with Lieutenant Arnold second with 209. The last named also won the MacKay trophy for a cross-country flight of 20 miles at 1,500 feet; it is significant of the times that only one other aviator was entered.

During the year fatalities were very high — four officers, one civilian, and one enlisted man.

Across the water occurred another prophetic event, reported thus by General George P. Scriven, Chief Signal Officer:

> The first review ever held of a complete aeroplane armada was held at Villacoublay, France, September 27, 1912. Seventy-two army aeroplanes were present, just returned from the grand army manœuvres at which they had achieved many triumphs. At the conclusion of the review, 20 airplanes rose as in a flock, hovered for a few moments over the parade ground, and then sped eastward to resume their stations on the German frontier.

At about this time, new world's records were set as follows: duration, 13 hours and 17 minutes; altitude, 18,537 feet; and speed, 109 miles per hour.

Meanwhile the need for development of the American service was becoming clearer. The Secretary of War, in response to a request of Congress, proposed on March 26, 1912, an appropriation of $2,000,000 for a continuing policy for a force of 120 planes and a series of training schools, which was well in proportion to European progress. This plan, however, was not adopted, and the service had to struggle on with very limited funds. The second appropriation, on August 24, 1912, was for but $100,000, actually less than the first; the third appropriation was restored to $125,000.

A flight very noteworthy for that time was made on March 28, 1913, by Lieutenant Milling, when he broke the American Army record for distance by covering the 240 miles between Texas City and San Antonio, and the record for endurance when he stayed in the

air a total time of four hours and 22 minutes. The flight was made over wholly unfamiliar country without landing places, and in its course Milling made a remarkable military sketch map, fairly complete in details and showing railroads, wagon roads, streams, woods, and so on. Another "brilliant flight" was reported at San Diego of 55 miles in one hour and five minutes at 6,500 feet.

The problem of training aviators was now clarifying also. The early practice of giving the preliminary training at the manufacturers' schools had now to be given up because "the general interest in the use of the aeroplane has fallen to such a low ebb that adequate training of military aviators cannot be given at these schools." The new system provided that preliminary training should be given by the expert military trainers, "of whom there are now two or three in the country," and that the final training should come in actual field work. On May 6, 1913, it was decided to abandon the College Park Station, most of the personnel and equipment being transferred to San Diego, California, where private owners were good enough to allow the Government the use of their land. By the summer of 1913, the school had 12 officers under instruction, 47 enlisted men on hand, and seven planes. The total number of planes in the whole Army was 15, and the total number of men who had qualified as military aviators was 11, of whom one was dead and four were in other branches of the service.

The first regular estimate for over $1,000,000 was that proposed for the 1915 Army appropriation, stated by General Scriven to be "necessary if the

United States is to keep abreast of developments in this science and cope with other first-class powers.'' Secretary Garrison, however, threw out over $700,000 for the balloon service and submitted to Congress a net figure of $300,000, including $25,000 to provide bonuses for manufacturers who exceeded certain degrees of merit. Surprisingly enough, this appropriation was reduced in hearings before the House Committee on Military Affairs beginning on December 4, 1913, to $250,000, despite the fact that it was ''trifling'' in comparison with those of foreign powers. The United States was shown to stand fourteenth among the nations in the total appropriations of $86,570,000 made in the previous five years since the first Wright flight, as follows: Germany, $28,000,000; France, $22,000,000; Russia, $12,000,000; Italy, $8,-000,000; Austria, $5,000,000; Great Britain, $3,000,-000; Belgium, $2,000,000; Japan, $1,500,000; China, $700,000; Bulgaria, $600,000; Greece, $600,000; Spain, $550,000; Brazil, $500,000; United States, $435,000. The United States stood equally low in the number of planes and pilots and the appropriations of the preceding year, as shown in the following figures:

	Planes	Pilots	Appropriations, 1914
France..........	260	171	$7,400,000
Russia..........	100	28	5,000,000
Germany........	46	52	5,000,000
England	29	88	3,000,000
Italy	26	35	2,100,000
Japan	14	8	1,000,000
United States....	6	14	125,000

Secretary Garrison protested vigorously against the reduction made by the House Committee before a Senate subcommittee, on the ground that it would be "extremely difficult to meet the needs of the Army in the purchase of aviation materials and the maintenance thereof for the existing year with $300,000, and a reduction of that amount would cause us grave embarrassment." He added:

> There has been a great deal of interest in this matter of aviation and Mr. Hay, the Chairman of the Military Committee of the House, had quite a long talk with me early in my encumbency about the desirability of forming a separate aviation corps and was considering the appropriation of a very large sum of money. I discouraged that plan because there were so many other things we had to ask for this year in the way of artillery and artillery ammunition that required large sums of money that we thought this development could wait. If you will look in the Book of Estimates you will find a statement of what other countries have been spending, running way up into the millions, and I then said it seemed to me that if we simply had enough machines and enough accessories and enough money to keep our men *au fait,* they will get the benefit of all this large expenditure in other countries because they will necessarily develop the art. I was not in favor of going into the millions this year, but I do think the estimate has been so legitimately modest that it was pretty hard to lose the $50,000 when the sentiment was really in favor of a larger appropriation for that specific thing.

General Scriven added that "we have either got to go ahead with aviation or stop." Nevertheless, Congress did not see fit to restore the figure to the original sum, and the service was restricted to $250,000 for the fiscal year 1915. Nothing shows better how purely experimental and negligible the

service was considered at that time. Up to December 1, 1913, only 47 men had been in training as aviators, of whom 19 had qualified, and only 24 machines had been purchased in the five years since Wright's first flight.

The situation was now becoming critical, especially for lack of officers to train as fliers. Moreover, public interest here had lagged in equal proportion to the increase of interest abroad. "America," said Colonel Samuel Reber, in charge of aviation, "which gave birth to aviation and led the world during the period of its early development, has been distanced by the great nations of Europe and with the exception of the hydroplane has contributed practically nothing to the science in the past three years. It has been surpassed not only in the number of pilots, types of planes, and engines, but also in engineering skill and construction." The enthusiasm that had swept over the country in 1910 in a series of meets and exhibitions at Los Angeles, Belmont Park and Chicago had been easily satiated by a few stunts, and apparently very little further was expected of aviation now that flight had been demonstrated as possible. Whereas Glenn H. Curtiss had won the first Gordon Bennett contest at Rheims, France, in 1909 from all comers, the French aviators who came to this country for the third meeting at Clearing, Illinois, in September, 1913, actually smothered all American competition.

The public has lost interest and does not support aviation as a sport; the Government has given but little aid in developing it as an adjunct to the national defense and has imposed no restrictions or regulations on its private use;

the output of aeroplanes and motors in this country is inferior both in numbers and in quality to that of the foreigners; our airmen are fewer in number and of less experience; no public-spirited citizen has endowed an aeronautical laboratory as has been done in many instances abroad; our technical colleges have not offered opportunities for the scientific training of aeronautical engineers. To place the development of mechanical flight on a correct engineering basis the cut and try methods of the pioneer must give way to both theoretical and practical investigation of the laws of aerodynamics and to careful tests of machines and the materials entering into their production.

Thus was American aviation officially described in 1913.

The number of qualified fliers was very low. At the beginning of 1913 it was estimated that of the total of 2,400 in the world, France possessed 1,200; England, 302; Germany, 320; Italy, 200; Austria, 60; the United States, 50; Belgium, 50; Holland, 23; Spain, 18. At the same time General Scriven said: "The number of civilians who have hitherto undertaken to fly for their own pleasure, for sport, or for money-making is fast diminishing, and it is doubtful whether in the event of war a score of men capable of making flights useful to the army could be obtained from civil life." The most serious phase of the situation, but one easily remedied, was that Army officers did not volunteer for this work. "The rewards offered," General Scriven told Congress, "have so far been inadequate and have not resulted in securing even the limited number for aviation duty now authorized by law." The service was freely described as "extra-hazardous," as eight officers and one enlisted man had been killed to date. Thirty

officers were authorized for the service, "if you can get them," but at present only 19 of the line and two of the Signal Corps were on duty. In all the five years since 1908, there had been but 75 applicants, of whom 17 had dropped out and 13 were disqualified temperamentally, three physically, and six otherwise. In all, but 32 had taken up flying and 13 of these had been relieved. "We cannot get them," Captain Mitchell said, "because they do not apply. They do not see any future in it."

Consequently, at this parting of the ways, a bill was presented to Congress on August 23, 1913, to increase the personnel, the prestige and the rewards of this "extra-hazardous" service. It provided for the formal recognition of aviation by establishing an Aviation Section within the Signal Corps, with an increase to 60 officers and 260 men. Aviation students were to receive 25 per cent. increase in pay; junior military aviators were to have the rank, pay and allowances of one grade higher and 50 per cent. increase in pay over their line commissions; military aviators were to be similarly treated except for an increase of 75 per cent.; and enlisted men while flying were to receive an increase of 50 per cent. Congress was told that "America was enormously behind Europe;" that no American motor had "remained in the air half as long as the best of European productions;" that "the industry is starving," the press apathetic, the public wholly disinterested; and that if the present bill were not passed, aviation would slip wholly into decay in this country. Apparently there was agreement on all sides that a drastic departure was essential if the art were to be saved, the only

question being as to whether a separate service should be created, as urged by the younger officers. The friction on this point, which had greatly retarded the service, broke out even before Congress, when General Scriven called the statements of one of the younger officers "not only offensive but untrue."

Finally, 11 months after the presentation of the bill, on July 18, 1914, just a few days before the outbreak of the European War, the bill actually became law. Its importance cannot be exaggerated, for in effect it created a flying service with an established personnel and rewards sufficient to attract the best kind of officers. From this time on aviation in the American Army, although held within the narrow confines of the whole American military establishment, was free to develop on a clearly defined basis.

CHAPTER II

DEVELOPMENTS THROUGH THE EUROPEAN WAR

Enormous and rapid development of aviation by the European belligerents — The United States debarred from participation by military secrecy — American military aeronautics in 1914 — The First Aero Squadron organized — The first specifications for military airplanes — Estimate of the airplane as a fighting machine — The $300,000 appropriation for 1916 — National Advisory Committee for Aeronautics created — Its investigation of aeronautical science in the colleges — Military aeronautics in 1915 — Defects of the Act creating the Aviation Section in the Signal Corps — New provision for aviation in the National Defense Act of June 3, 1916 — The crisis on the Mexican border and a special emergency appropriation — Aerial service with the Pershing expedition — The $13,000,000 appropriation for 1917 — Secretary Baker on the needs of the Air Service — Its reorganization under Colonel George O. Squier — Problems of equipment and personnel — Military aeronautics in 1916 — The $10,800,000 appropriation for 1918 adopted after our declaration of war.

Not until the outbreak of the European War in 1914 was mankind destined to complete the conquest of the air. Where, in the half-dozen years since Wright's first flight, the various nations had crept slowly forward, largely through the untiring efforts of a few zealots, the terrible demands of the life and death struggle of the nations drew forth a genius of development. The various air services, new, inspiring and romantic, quickened imagination the world over. The vital import of a mile or two more of speed an hour, or a little higher climbing ability, brought forth in a few months from the organized science of the world developments which would have

taken a decade or more under the previous conditions of disorganized, undirected effort.

From this great development the United States was for two and a half years entirely shut off by the heavy curtain of military secrecy which the belligerent Governments were forced to erect. Only an occasional flash of light shot through to indicate what was going on in the scientific laboratories and the factories behind the battle lines. Nevertheless, there was ever present in aerial warfare so much to stimulate the imagination and the sense of chivalry that the American public was eager for every detail, and followed aviation development with an interest which it was not possible for a non-military people to extend to other more technical phases of the distant struggle.

America's aviation leaders were fully alive to the vital military importance of the new art. General Scriven, in his annual report written not two months after the Great War broke out, used the brief experience abroad to drive home once again his demand for an adequate air army:

> It seems probable that the airplane, and to some smaller degree all aircraft, have altered, not the principles of strategy, which are immutable, but the theory and application of grand tactics. It now appears that the actual game of war is played openly with the cards laid on the table, and opportunity no longer given for inference as to concealed movements or surprise, perhaps not even for the exercise of the high military quality of anticipation of the unseen movements of the adversary.

The Aviation Section was still almost negligible in numbers, the parent organization in the Signal Corps having struggled through the lank years of apathy

and experimentation barely able to keep alive and wholly unable to develop on a broad scale. Nevertheless, the record for the fiscal year before the war had been so promising, comparatively, that General Scriven in his 1914 report stated that "the aviation work of the Signal Corps is on a very satisfactory basis." An amount of flying quite unprecedented had been carried on at San Diego. During the year 3,340 flights were made, 796 passengers carried, and 747 hours spent in the air. Many flights were "at high altitudes, ranging from 5,000 to 12,000 feet," and a new American cross-country distance and duration record for a machine carrying a pilot and one passenger was made on February 14, 1914, when Lieutenant Dodd at San Diego covered 246 miles in four hours and 32 minutes.

The San Diego school, located by courtesy on land loaned free of charge, which the Government might be requested to vacate at any moment, developed favorably despite the lack of instructors and planes. The officers, General Scriven said, "with little or no experience and with no precedent to guide them, have had to train themselves and their subordinates at the same time." Civilian instructors were added during the year, as "teaching men to fly is probably the most dangerous occupation in the world, and men who can do this work and do it well are very rare and their services are cheap at almost any price." Three more accidents with four deaths occurred during this period, which led to the final decision to abandon the pusher type of plane in favor of the tractor, as the former in an accident tended to drive the aviator straight into the ground with the whole weight of the

FUSELAGE DEPARTMENT OF THE CURTISS AEROPLANE COMPANY, CHURCHILL PLANT, JANUARY, 1918

engine on top of him. The change, however, further held up training, as only one or two officers knew how to manage the tractor.

During this year the first tactical aerial unit in America's history was created. This was the First Aero Squadron, formed at San Diego in September, 1914, under orders of December 4, 1913. It consisted at the time of 16 officers, 77 men, and eight planes, and was soon destined to see active service across the sands of Mexico.

One of the best indications of the condition of aeronautical science at that time is found in the fact that on July 1, 1914, the first specifications for a highly specialized plane, that is to say, a plane that not only could fly but could also answer certain definite military requirements, were issued. The purpose was to encourage the few lean manufacturers and to develop new types of planes; the details are very illuminating. They called for a "biplane, enclosed fuselage, two seater, dual control, with a maximum speed of not less than 70 and a minimum speed of not more than 40 miles per hour when carrying fuel and oil for four hours' flight at 70 miles per hour and a useful load of 450 pounds and under these conditions to climb 4,000 feet in 10 minutes." These conditions were considered very strict. Only 12 competitors entered, most of whom were known not to be able to fulfill the requirements. Fortunately, at this time the engine situation was beginning to improve, after a long period when, as General Scriven said, "it looked as though it was absolutely hopeless to depend on American manufacturers to produce a satisfactory aeroplane engine."

Just at the time the war broke out in Europe, the 1916 Army appropriation was being estimated. A total estimate of $1,006,300 was submitted to Secretary Garrison, providing for two complete squadrons of 16 planes and six planes for insular service, together with lighter-than-air equipment. Mr. Garrison, however, threw out the latter, reduced the airplane figure by $100,000, and sent an estimate of $400,000 to Congress, which began hearings before the House Committee on Military Affairs on December 8, 1914.

General Scriven took advantage of this first hearing after the outbreak of war. Airplanes had shown, he said, "that they are the most tremendous implement for reconnaissance and for the gathering of information that modern war has ever seen. As a fighting machine, the aeroplane has not justified its existence." They could spot for artillery, he said, by smoke bombs or by dropping fragments of tinsel paper, which in falling through the sunlight gave out flashes of light. A lifting power of only 150 pounds, however, rendered them useless for offense.

Much concern was expressed by the Committee as to whether touch was being kept with foreign developments, to which Colonel Reber answered: "I think we are — as far as it is possible to say we are keeping abreast of conditions that we do not know anything about." This complete exclusion from scientific developments abroad, wholly unavoidable as it was, was destined to have a most serious effect on America's later preparation.

The industrial situation also was very serious. One hundred machines, General Scriven said, could not be

secured in less than a year's time, for up to then only three companies had done business for the Government, and one of them had recently ceased. Said Colonel Reber:

> Inasmuch as they have practically no orders at all except what they get from the Government, they can hardly make both ends meet. In fact, two manufacturers have told me they are behind the game and hanging on by their eyes, hoping times would get better. I do not think any aeroplane manufacturer is making money out of the Government or anyone else. There is no combination among them because all are so poor they need the business.

All of which led Chairman Hay to call it "a pretty serious situation."

The Government then had but 11 planes and two training planes, with 11 about to be ordered, and a force of 160 men as against 2,600 for Germany and 3,000 for France. The appropriation asked called for a front line of but 32 planes, with a reserve of 50 per cent. Figures were given to show that the last budgets before the war were: Germany, \$45,000,000; France, \$12,800,000; Russia, \$22,500,000; Austria, \$3,000,000; Great Britain, \$1,080,000; Italy, \$800,000; United States, \$250,000. Secretary Garrison's estimate, therefore, was well described by one of the Committee as very modest, and it is all the more surprising that the amount finally authorized came to but \$300,000, possibly on the theory expressed by Senator McKellar, that airplanes "have proved worthless to a very large extent, and we are the gainers by not having spent so much."

Nevertheless, at this time the attention of the country's foremost scientists was being aroused to aero-

nautics to a degree never before exhibited. The war abroad had driven home the realization that in this most complicated of sciences America must mobilize her best minds if she were not to be hopelessly outdistanced. Consequently, a bill approved by President Wilson was introduced into Congress, and became law as a part of the Naval Appropriation Act of March 3, 1915, establishing a National Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight. The sum of $5,000 a year for five years allotted for this work stands out as a sharp indication of the actual value, expressed in dollars and cents, attached to it. Nevertheless, the Committee, in borrowed offices, at first in the ante-room of the Secretary of War, set out on its neglected task with a strong membership, composed by law of two members each from the Army and the Navy air services, one each from the Smithsonian Institution, the Weather Bureau, and the Bureau of Standards, and not over five other civilian members.

The War Department's plans for aviation were outlined to the Advisory Committee in a letter from General Scriven on April 16, 1915, showing that there was in mind the development of the school at San Diego, the establishment of the first "aviation center" at San Antonio, Texas, and the building up of a first-line force of four squadrons of eight planes each with 50 per cent. replacement and two training planes, a total of 50 planes. "In the light of experience, however, and of present information," said General Scriven, "I now believe these numbers somewhat small even for present needs." He added that he

would ask for a front line of as much as 75 planes at a cost of $750,000.

One of the most extraordinary flashes of light on the standing of aviation at that time came when on August 1, 1915, exactly a year after the outbreak of the European War and seven years after Wright had made his first flight, a letter was sent by the Committee to 112 colleges, 22 aeronautical societies, and eight manufacturers, asking what they had done, were doing, or contemplated doing towards the conquest of the air. Only four manufacturers replied and these in the most elementary terms. "The interest of the colleges," the Committee summarized, "is more one of curiosity than that of considering the problem as a true engineering one requiring development of engineering resources, and therefore as not yet of sufficient importance to engage their serious attention." About 25 educational institutions had been interested in one way or another, some of which had dropped the subject entirely, and the majority had taken only the most elementary steps. Institutions such as Yale, Cornell, Michigan, Brown, Georgia School of Technology, Worcester Polytechnic, Minnesota, and Pennsylvania State College all reported lack of funds. Only the University of Michigan and the Massachusetts Institute of Technology reported a regular course of instruction and experimentation. Cornell was interested in glider experiments, and Pennsylvania State College possessed an airplane five years old. Obviously, in this, the second year of war abroad, the interest in the scientific development of aviation was very limited.

Meanwhile, although the Aviation Section was

growing very slowly within its narrow limits, its achievements were becoming more and more substantial. A new American altitude record for a single-seater plane of 17,441 feet was established on October 4, 1914, by Captain H. LeR. Muller. A new American two-seater altitude record of 11,690 feet was established on January 5, 1915, by Lieutenant J. E. Carberry, pilot, and Lieutenant A. R. Christie, observer. Ten days later Lieutenant B. Q. Jones established a new American endurance record of eight hours and 52 minutes, and on March 12, a new world's record of seven hours and five minutes for a pilot and two passengers. During the fiscal year 1915 Government planes were in the air nearly twice as long as in the year before, and the number of passengers was more than doubled. At that, only 1,269½ hours were flown and 1,730 passengers carried by the whole Army air service.

The extreme necessity of preparedness far in advance was again urged by General Scriven in his 1915 report. "The difficulties surrounding the creation of an adequate aeronautical service after the outbreak of hostilities," he said, "have been vividly illustrated during the past year and the great inconvenience and dangers resulting from the lack of an adequate aeronautical personnel and materiel have been demonstrated so forcibly that comment is unnecessary." This statement was reinforced by the fact that there were only 30 officers, including 20 junior military aviators and four qualified students, and 177 men in the Aviation Section. A confidence in the aircraft industry was expressed by General Scriven which was to prove later to have been seriously misplaced.

Since the outbreak of the European War, several new factories had sprung up with bold claims of production, but the Government did not have the accurate information necessary to judge their capacity. Fortunately, so far as engines were concerned, all possibility of misapprehension had been removed when the complete shutting off of foreign supplies had left this country high and dry.

By early 1916 America's international situation had become alarming, and the agitation for military preparedness had assumed definite proportions. The unfolding of the magnitude of modern warfare had disclosed America's defenselessness in a dramatic way, and as a result a series of changes were made in the whole military organization, including the Air Service, through the National Defense Act of June 3, 1916.

Very serious weaknesses in the basic legislation of the Air Service were early developed in the hearings before the House Committee on Military Affairs beginning on January 18, 1916. Not only did the law restrict it in size to a handful of 60 officers and 260 men, but it imposed further restrictions that made it extremely difficult to attain even that small strength. Aviation duty, which was fully voluntary, was restricted to unmarried lieutenants of the line under 30 years of age, which class at the time included only 668 officers. The tendency, therefore, was "to fill the Aviation Section with young and inexperienced officers, the majority of whom were Second Lieutenants," as is shown by the fact that on August 16, 1915, only five of the 29 officers on duty were above that rank, and at the same time to keep out many

desirable men who happened to be married or over 30 years of age. Indeed, of the 60 officers authorized in the basic Act passed 18 months previously, only 46 were actually on duty. Thirty-eight new officers had been added to the 19 on duty at the passage of the Act, and nine had been relieved and two killed. Of a grand total of 43 fliers trained since the beginning of aviation, 14 had been relieved and six killed, leaving 23 actually on flying duty. No real reinforcement was possible from civilian aviators in case of a crisis. Of the 300 licensed pilots in the United States outside the Army, not a handful were good cross-country fliers. It was generously estimated that possibly 100 might be secured after a month's training, but the fields available could train only 25 men at a time, as there were but 19 planes on hand and six in manufacture.

Here developed an early instance of disagreement between the Air Service and the War Department. The former most vigorously requested a total of 18 squadrons, one for each of the seven proposed tactical units, five for the Field Artillery, three for the Coast Artillery, and three for overseas, with a total strength of 368 officers and 2,360 men and between 432 to 648 planes. The War Department, however, cut this programme practically by two-thirds, allowing but 133 officers and 710 men, and Congress sustained the Department over both the protest and the compromise suggested by the aviation authorities.

The rapid distancing of the United States in scientific development was brought out at the hearings. There had been no experimentation with foreign machines, Colonel Reber said, not only because it was

next to impossible to obtain them, but also because "we have been so poor we have just been able to keep our own equipment going without doing any experimental work that has amounted to anything at all."

All the legal restrictions complained of were cleared away by Congress in the National Defense Act of June 3, 1916, and an appreciable increase in personnel was allowed. An immediate strength by July 1, 1916, of one major, 11 captains, and 65 first lieutenants was authorized, with an eventual strength by July 1, 1920, by annual increments, of one colonel, one lieutenant-colonel, eight majors, 24 captains, 114 first lieutenants, and 4,000 men. At the same time an Officers' Reserve Corps and an Enlisted Reserve Corps were authorized, consisting of 16 majors, 48 captains, 232 first lieutenants, and 2,000 men.

Meanwhile, early in March, had occurred the raids across the Mexican border and the entry into Mexico of the punitive expedition which was destined to revolutionize the whole aerial programme along with the rest of the military establishment. The Pershing expedition, with its long, tenuous line across the sands of northern Mexico, afforded the first practical demonstration of the value of aircraft for reconnaissance in the history of the American service, and showed, as nothing else could, the vital necessity of airplanes.

The First, and only, Aero Squadron, equipped with eight old and low-powered planes and commanded by Captain B. D. Foulois, was at once rushed to General Pershing's base at Columbus, New Mexico. The altitudes encountered, up to 12,000 feet, the vast distances, and the lack of good landing grounds made the theatre of northern Mexico one of the hardest to

operate in that any army had ever entered, and the original machines, which, with only 90 horse power, could not, as Secretary Baker said, fly as high as the mountains, were rapidly used up in accidents on March 19 and 20 and April 6, 14, 19 and 24.

A special emergency appropriation of $500,000 was therefore asked of Congress. "We now have actual field operations going on," Secretary Baker said. "The aeroplane service is, of course, the scouting service, and I would like, if possible, to buy some additional aeroplanes at once, taking advantage of the experience that manufacturers in this country have had from the European experience, and send them down there and get the value of testing them under actual field conditions." The appropriation asked for, the greatest yet authorized for aviation, was approved on March 31, and allowed the Air Service to bring itself for the first time, even in a small way, up to date. Twelve new 160-200 horse-power Curtiss planes at $12,000 each were bought as rapidly as possible, the best available in the United States, with Lewis guns, automatic cameras, incendiary and demolition bombs, and wireless equipment.

From the time of their arrival on the border the series of raids ended. Over 3,000 flights were made across this hostile, sandy desert, for a total of 30,000 miles, without a fatality. A great amount of scouting over country in which cavalry and infantry could not operate was carried out, and the first regular aerial mail route maintained by the United States was opened over the 110 miles from Columbus to Field Headquarters at Colonia Dublan, airplanes covering the distance in 66 minutes. On August 22, 1916, the

EXPERT WOODWORK ON THE WINGS

TRUEING UP THE FUSELAGE

first aerial review ever held by the United States Army passed before Brigadier-General John J. Pershing "somewhere in Mexico."

The peculiar success of aviation in Mexico had its corresponding effect in Washington. Aviation had proved beyond dispute to even the most scoffing that it was no longer experimental or freakish. Undoubtedly much of the support which Secretary Baker and General Pershing later gave to the Air Service had its roots in this demonstration. At the same time it brought about the first appreciable aviation appropriation ever made in the United States — that for the fiscal year 1917, of $13,281,666, enacted on August 29, 1916.

The estimate first made, sent in on October 13, 1915, by General Scriven, had called for only $3,728,743; this was later cut down, when Secretary Baker came into office in March, 1916, to $1,222,100, on which sum the early hearings, beginning on April 6, 1916, were held. Said Secretary Baker before the House Committee on Military affairs:

> Every country in Europe, even England, is very carefully guarding from our military observers their developments in aeroplanes. The Germans, the French and the English do not allow our observers to acquire their improvements in aeroplanes, and the only way we have access to that information at all is that some of the Europeans are ordering aeroplanes made in this country, and so our manufacturers know their specifications.

Secretary Baker also illuminated the unfortunate internal situation which had prevailed for a long time in the Aviation Section. His sympathetic explanation was:

The men in the Aviation Corps have been almost exclusively comparatively young men, very young men indeed, and they have been engaged in an art desperate, daredevil, hazardous indeed, so that they have had an attitude towards life and towards themselves that men have who are engaged in an especially hazardous service. Being fliers, they have had rather a disposition to chafe at the restraint and discipline which was made for more normal kinds of service, feeling that they were not adapted to the regulations and restrictions of men who were not engaged in so unusual an occupation. In other words, they had an impatience at being controlled by men who did not themselves know the business in which they were engaged. I do not want to be understood to criticise these young men. They are pioneering for the army and the United States and their exploits are superb.

The net result of it all is that I am going to reorganize the entire Aviation Section We are going to have the advantage of the knowledge and experience of Colonel Squier, who has for many years been a distinguished scientist in the Signal Service, and who has recently been in Europe observing the aeroplane.

The Secretary was equally frank about America's backwardness in aviation, especially in motors. "Europe," he said, "has very plainly passed us in the development of the aeroplane motor. All the machines made in this country to go abroad are tried out as to motor and I am told that in most cases they take out the American motor and put in their own." He did not endeavor to ascribe this to any one individual's fault, but rather to an unforeseeable advance engendered by the demands of the war.

It seems to me that Congress has been as generous as the state of the art justified and that the army division in charge of aviation has shown very great zeal and enterprise in trying to develop it. In the Aviation Section there has

been some feeling that Congress was not sufficiently generous but it is easy to think of some things that might have been done. The amazing development of the art is the outgrowth of the European war. I think that both the Congress and the army can feel they have really done very fairly by it.

Secretary Baker presented rather startling figures of what had been done to date. In all the six years since the first Wright plane had been purchased, only 59 planes had been bought by the Government. Of these, 21 had been condemned, 11 destroyed in accidents, and one preserved at the Smithsonian Institution. Only 23 were in active service, 11 at San Diego, eight in Mexico, and four at Manila. With the coming of the Mexican crisis, however, a complete reorganization of the military establishment became necessary, with a great increase in every branch. The Air Service was brought up to a strength proportionate to the increased force necessitated by the mobilization on the Mexican border, and for that increase came the $13,000,000 appropriation.

In May, 1916, the promised reorganization was carried through by Secretary Baker with the bringing back to this country of Colonel George O. Squier, who had been for four years Military Attaché at London. Colonel Squier was well known in aviation circles, having largely drawn up the first Government specifications ever published (those of the Wright plane in 1908) and having been among the first passengers to go up with the Wrights. Moreover, he had achieved international reputation in electrical science by developing a new method of rapid telegraphy based on the use of alternating current with the polarizing

photochronograph, and by practically doubling the capacity of the ocean cables through the employment of a single-phase alternating current of the sine-wave type operating with the Morse code. Colonel Squier returned with all the prestige attaching to one of the handful of Americans who had seen the European War from the inside. He could speak with authority on what was actually going on abroad and could reinforce his arguments with personal experience. He was, therefore, in a splendid strategic position, which was further strengthened when he was made Chief Signal Officer on February 14, 1917.

The development made possible by the 1917 appropriation was continued when the 1918 estimate was submitted on September 13, 1916. This called for $21,600,000, but it was ordered reduced by 25 per cent. in accordance with the general policy of reduction in the War Department, and later to $10,800,000 by inclusion of some items in the Fortifications bill. Less than a month before Germany declared for unrestricted submarine warfare, hearings on this appropriation began on January 5, 1917, before the House Committee on Military Affairs.

Colonel Squier, on whom the brunt of the testimony fell, stated that the great appropriation of over $13,000,000 of August 29, 1916, had placed before the Service a double problem: "First, getting equipment made that was safe and efficient, and second, the personnel trained to fly that equipment, a team which we must keep abreast and not let get in tandem." The equipment problem, he said, had been attacked by the revolutionary practice of placing Government inspectors, over 40 in number, in the various factories.

Heretofore we had bought finished aeroplanes with paint and dope covering them, and there might be defective wooden or other parts that could not be detected. So we started a small civilian instruction corps to put into the factories whenever we got a contract, to stay there and watch every step of the manufacture and to report daily, so that every piece of wood and metal that was to go into a Government aeroplane was to be known and stamped as the best that could be obtained. . . . This has led to the improvement of the aviation equipment in a marvelous way, so that the equipment we are getting is as good, I am sure, as this country can produce and is improving very rapidly.

This improvement had a splendid psychological reaction on the fliers. "They are flying," Colonel Squier said, "a distance equal to many times around the world without an accident, and it is difficult to think even an automobile could go that far without an accident." In fact, from January 1 to December 26, 1916, 7,087 flights for a distance of 251,755 miles and a time duration of 3,356.56 hours had been made without a fatality.

The industrial situation was frankly pictured as critical. Manufacturers had been confronted, Colonel Squier said,

by the fact that there has been no buying market for aeroplanes in this country, and of course without a buying market you cannot develop an engine or an equipment; consequently we are very much behind Europe, which under the spur of war, has gone forward in a marvelous way along these lines. The flying movement abroad is simply prodigious.

The appropriation was absolutely necessary, Colonel Squier contended, as "the American manufacturers want to realize that they can go to work and count on

some sort of a general policy on a reasonable scale; otherwise they are not going to put their money into these things."

Moreover, the expenses of the Air Service were very large. Colonel Squier pointed out that it cost $50,000 to keep a plane in the air one year, as it must ordinarily be replaced four times, and the life of its engine he estimated at 300 hours, with a cost of $35 to $50 per horse power as against $3 to $5 per horse power of an automobile engine. Thus to form a new squadron of 12 planes and maintain it for a year would cost $800,000 for the first year and $600,000 annually afterwards. Said Colonel Squier:

> It would surprise you to learn how highly organized and complicated the Air Service is. There is nothing else like it. It is the acme of professional and mechanical skill. For instance, it requires five skilled men for each plane. When a machine comes down in war, the men go right at it, like the attendants at a horse race; they go at every single part of it instantly; they examine every part of it to see that it is right before it flies again.

This work, he said, appealed to mechanics very much, for "it is a sort of vocational school." At that time the enlisted force stood at 800 out of an authorized strength of 1,800, with an authorized strength for the following year of 3,200. This was sufficient to equip the seven old squadrons, six reserve squadrons, and four new ones. At the same time there were less than 50 trained military aviators, eight or nine enlisted fliers, 30 students at San Diego, and 35 in reserve immediately available. Up to November 30, 1916, there had been 222 applicants to enter the Service, of whom 141 had been accepted, 33 relieved,

one resigned, 14 killed, and 93 left on duty; of the last 45 were qualified fliers and 43 students.

In all the years to date only 121 machines had been delivered to the Government. Of these, 21 had been destroyed, 27 were out of service, and only 73 were actually available, including 30 at San Diego, 18 at Mineola, Long Island, 14 at Columbus, New Mexico, seven at San Antonio, Texas, and four at Manila. There were under order 302 machines from 12 companies, including five small companies, and 56 approved but not actually ordered. The personnel comprised three majors, nine captains, 33 first lieutenants, and 458 enlisted men on December 7, 1916.

An argument destined to have weight at every future consideration of aviation was brought out at this hearing by Colonel Squier.

> After this war the armies in general will disband or shrink, but the Air Service is going to stay where it is and go on. It is an asset that is going to remain. All we learn in this war about aerial navigation will be applied to the uses of civilization in the peace which follows. It is the one point of permanent gain, and that is why this country is safe in putting money into it.

The bill carrying the full appropriation of $10,800,000 was enacted on May 12, 1917, just five weeks after the declaration of a state of war with Germany.

CHAPTER III

AMERICA'S EARLY WAR PROGRAMME

Resumption by Germany of unrestricted submarine warfare — Declaration of a state of war — Its anticipation by the War Department — Aviation in the original war programme — Urgent war appropriations — The serious situation in the airplane industry — Industrial conference of the National Advisory Committee for Aeronautics — Its recommendations — Aircraft Production Board created — Its functions, powers, and personnel — Howard E. Coffin appointed Chairman — Joint Army and Navy Technical Board created — Original programme of the Aircraft Production Board — The alarming patent situation — Its solution by the National Advisory Committee — Aircraft Manufacturers' Association formed and vested with all patents of its members — The problem of training aviators — The Canadian system adopted — Coöperation of scientific schools secured — Six "ground schools" inaugurated — Three flying fields located and built — The situation at the end of six weeks of war.

On January 31, 1917, at five o'clock in the afternoon, Count von Bernstorff delivered to Secretary Lansing Germany's notification of her decision to resume from the following day unrestricted submarine warfare. This action, which, although expected, came earlier than anticipated, placed the issue of war or peace squarely before the United States.

On February 5, five days after the U-boats had been unleashed and two days after the breaking of diplomatic relations with Germany, the Aviation Section, with the other branches of the War Department, was requested to prepare an estimate covering its needs in an army consisting of the Regular Army, the

National Guard, and 500,000 volunteers. This estimate, submitted on February 16, came to a total of $48,666,666, and provided for an air service directly proportional in strength to the rest of the military establishment rather than for a great, separate, fighting force. The General Staff regarded aviation as a correlative branch with infantry, artillery and cavalry, all balanced and adjusted to each other in a well proportioned unit. The conception of developing the Air Service enormously beyond this proportional strength only came three months later as a result of direct touch with Europe.

Progress on the general programme of the War Department, however, required considerable time, as the personnel was small and inexperienced in the face of the tasks before it. Moreover, all during February and March there was uncertainty as to whether Congress would go to the length of declaring war. This uncertainty was not finally cleared away until the sinking of three American ships, the *Vigilancia,* the *City of Memphis* and the *Illinois,* all reported on the single day of March 18, brought about the formal recognition of a state of war on April 6.

This triple indication of Germany's ruthlessness once again quickened action. On March 21 another general memorandum was sent through the War Department:

> The Secretary of War desires that you prepare estimates for the supplies pertaining to your bureau needed to equip an army, including the present Regular Army and the National Guard, of one million men organized into 32 infantry and 4 cavalry divisions and Army Corps sufficient for 12 Army Corps.

A second memorandum to the same effect was sent out later in the same day, and on the 26th a third, which stated: "It is desired that estimates called for be submitted not later than 9 a. m., Thursday, March 29th."

The aviation estimates, rushed through by Colonel J. B. Bennett, Major Foulois and Major Wallace, were sent in on the 28th, and slightly modified on the 30th. They called for $54,250,000, to provide a force of 1,850 aviators and 300 balloonists. The details of this first estimate, as conceived by American officers under the plans of the General Staff and unaffected by Allied pressure, are interesting as showing the aerial programme this country would have adopted if left to itself:

32 Infantry Divisions	$25,600,000
4 Cavalry Divisions	3,200,000
16 Aero Squadrons (for Army Corps Headquarters)	12,800,000
16 Balloon Companies (same)	3,300,000
9 Schools, 50 men each every 4 months, or 150 yearly	10,800,000
Civilian Training, 500 pilots	700,000
Lighter-than-air Equipment	1,000,000
Civilian Training, 300 balloonists	150,000
	$57,450,000
Less equipment on hand (4 Aero Squadrons)	3,200,000
	$54,250,000

This estimate, later reduced to $43,450,000 by the $10,800,000 appropriated on May 12 for the year 1918, was included in the urgent deficiency war estimates submitted to Congress on April 30. The

figures for aviation remained unchanged and hardly questioned during a considerable delay over other items of the bill, which did not finally become law until June 15.

Meanwhile, with the country standing on the verge of war, some realization of the seriousness of the industrial situation in regard to airplanes began to be had. On February 3, the day of the severance of relations with Germany, a total of 293 planes were reported by a special investigating committee to be on order, of which 38 had been delivered by two companies and 173 more were expected by June 30. In all, only 11 companies were under contracts, of which two were to be cancelled. It is peculiarly illuminating of the situation at that time that the National Advisory Committee for Aeronautics, a body of scientists formed to study the technical problems of flight, should have been the means of bringing together the Government and the manufacturers for the most important conference yet had. This well shows the lack of cohesion between the Government and producers essential to a big programme, as well as the rather amateur methods of those early days.

Less than three weeks before the United States entered the war, on March 22, a joint meeting was called by the Committee, including Army and Navy officers and representatives of practically all the leading airplane manufacturers. Dr. Charles D. Walcott, the Chairman, declared that America had "hardly made a beginning" in aviation, and continued:

> Though millions may be available for a specific purpose in time of great need, no amount of money will buy time. Even the most generous preparations do not open up the

years that have passed and enable us to carefully lay the foundation of a great industry and a great aerial army through the education of engineers, manufacturers, teachers and all the wide variety of personnel required.

Here indeed, although unrealized at that time, lay the crux of the situation. America, with all the apathy of peace, had been outdistanced by the belligerents in the science of aviation. It is easy to appreciate now that the lack of realization of the engineering and industrial difficulties was one of the great causes of America's late start.

Only 12 companies, Dr. Walcott reported, were than capable of Government work, 59 planes having been ordered and 54 delivered from four companies in the eight years before 1916, and during 1916, 366 planes ordered and 64 delivered from nine factories. To meet this situation Dr. Walcott suggested coöperation between the Army and the Navy, concentration on one standard training plane, the standardization of parts, the simplification of inspection, the mobilization of essential materials, such as spruce, and the clearing up of the patent situation.

The information brought out at this meeting proved so serious, and the inability of the manufacturers to meet the Government's programme was so evident, that on March 29 the Advisory Committee addressed a letter to the Secretaries of War and of the Navy and to the Council of National Defense, bringing out the vital necessity of laying down a continuing programme in order to justify the entrance of the manufacturers into airplane work on a large scale. "At present," the letter said, "the industry may be divided into two parts, the Curtiss Airplane and

WING DEPARTMENT OF THE DAYTON-WRIGHT AIRPLANE COMPANY, PLANT 1, FEBRUARY, 1918

Motor Corporation, and others.'' Therefore, "if it should be thought necessary to provide for as many as 3,000 planes for the fiscal year 1918, 4,000 planes for the fiscal year 1919, and 5,000 planes for the year 1920,'' a three-year programme should be laid down and certain special materials, such as spruce, mobilized far ahead.

On April 3, immediately after word came from the Capitol that President Wilson had asked for the declaration of a state of war, the Committee sent out the following telegram to the few manufacturers of planes and engines whose records seemed to justify Government contracts:

> Can you provide training reconnaissance aircraft? If so, state types, facilities for manufacture, date of delivery of first machine, number that can be delivered weekly thereafter. Same data in regard to engines.

The replies to this telegram were so fragmentary as to offer practically no basis on which to proceed; they were turned over to S. D. Waldon, as a special Committee on Production, to follow up in any way that seemed wise.

The first step toward the formation of what later became the Aircraft Production Board was taken a week later, on April 10, after a committee had considered Secretary Daniels' proposal for an Air Service with a civilian head. A very vivid realization of the industrial difficulties of the airplane programme and of the necessity for their handling by men of the widest business experience had been impressed upon the Committee through its meetings with manufacturers and its dependence upon the work

of such production experts as Mr. Coffin and Mr. Waldon of the Council of National Defense. Accordingly, on April 10 the Advisory Committee urged upon the Council the appointment of an Aircraft Production Board, the purpose of which was defined as follows:

> The function of this Board shall be to consider the situation in relation to the quantity production of aircraft in the United States, and to coöperate with the officers of the Army and Navy, and with other departments interested in the production and delivery to these departments of the needed aircraft.

On April 12 the Committee went even further, proposing to the Council the most ambitious aviation programme yet suggested. This called for an appropriation of 300 millions for a joint Army and Navy three-year programme to train 2,500 men the first year and 5,000 the next year in 12 new preliminary schools, and to encourage the industries to their maximum attainable capacity of 3,700 planes in 1918, 6,000 in 1919, and 9,000 to 10,000 in 1920. It is interesting to note that 3,700 planes was the maximum thought attainable for 1918.

The Council of National Defense was so overwhelmed with the multitude of new duties suddenly thrust upon it that another month elapsed before information was in hand on which to work out the suggestion of the National Advisory Committee. On May 16, however, a resolution was passed establishing the Aircraft Production Board, without any legal powers but authorized by the Council, itself an advisory body, to offer advice to both the Army and the Navy as to the quantity production of aircraft and

as to problems of engineering, specifications, standardization, inspection, schools, supply depots, priority, and in short anything that would tend to provide an adequate materiel.

Howard E. Coffin was named by the Council as Chairman and organizer of the new Board. Mr. Coffin, one of the founders of the Hudson Motor Car Company and President of the Society of Automotive Engineers, had first come to Washington some time before as one of the Society's appointees to the Naval Consulting Board organized by Secretary Daniels. Here, as Chairman of the Committee on Industrial Preparedness, he had made an industrial inventory of the United States, and in 1916 he had been appointed by President Wilson to the new Council of National Defense. Mr. Coffin's first duty was to organize a strong Board for the work ahead. General Squier, Chief Signal Officer of the Army, and Admiral David W. Taylor, Chief of the Bureau of Construction and Repair of the Navy, were chosen as heads of the Army and Navy Air Services, and three civilians were brought in. E. A. Deeds of Dayton, Ohio, formerly General Manager of the National Cash Register Company, President of the Delco Company, and one of the industrial leaders of the Middle West, agreed to spend three or four days a week on the work, little foreseeing at the time how much of his life and his hopes it would absorb. R. L. Montgomery, of the Philadelphia financial house of Montgomery, Clothier and Tyler, and S. D. Waldon, formerly Vice-President of the Packard Motor Car Company, were the others selected.

During the next few weeks the Board stepped

boldly into the emergency, and promptly took over, through its relationship with the Army and the Navy, the laying down of policies of production and the recommendation of contracts. The Board had almost as much information as to the actual industrial situation as the regular military authorities, and it had the additional advantage of wide personal experience in big business development.

These early days saw also the formation of the Joint Army and Navy Technical Board to determine the complex problem of types. Many of the Army and Navy fliers felt that in the sudden expansion men unfamiliar with flying might run away with these decisions, and accordingly they secured the appointment by the Secretaries of War and of the Navy of the Joint Technical Board. This Board at once took over the whole problem of types, reporting to the Aircraft Production Board the types desired for production. On May 22, six weeks after the outbreak of war, after conferences with the Canadians, its formal programme was laid down, requesting the Aircraft Production Board at once to secure samples and drawings of half a dozen each of the most successful foreign planes and engines.

On June 12 the Aircraft Production Board, as a result of conferences with the Army and Navy Technical Board and with the manufacturers, drew up a new and final training schedule showing the actual decisions reached to date on a programme which then stood at 2,330 primary planes and 144 advanced planes. It is interesting to note that at that early time the Curtiss Company led the list with orders for 1,108 planes, while two new companies, the Dayton-

Wright Airplane Company and the Fisher Body Corporation, came second with 500 each. The whole reliance for engines was on four companies. This original programme so well shows the situation at the time that it is given in full:

PRIMARY TRAINING

			Estimated Cost
Standard Aero Corporation	150	"J" Training	$ 900,000
Curtiss Aeroplane Company	600	"JN"	6,300,000
Curtiss Aeroplane Company	400	"JN"	4,200,000
Hall-Scott Motor Car Company	1,000	"A7A" engines	2,300,000
Nordyke-Marmon Company (Hall-Scott)	1,000	"A7A" engines	2,300,000
L. W. F. Engineering Company	72	"JN"	432,000
Pacific Aero Products Company	36	"JN"	216,000
Dayton-Wright Airplane Company	500	"JN"	3,000,000
Aeromarine Engine and Sales Company	72	"Training"	432,000
Fisher Body Corporation	500	"JN"	3,000,000
			$23,080,000

ADVANCED TRAINING

L. W. F. Engineering Company	36	Tactical Land Reconnaissance	$ 583,200
General Vehicle Company	100	Gnome engines	455,000
Curtiss Aeroplane Company	36	"R-4"	669,600
Curtiss Aeroplane Company	72	"R-6"	1,425,600
Wright-Martin Aircraft Company	500	Hispano-Suiza engines	2,750,000
			$5,883,400

The Board's attitude towards battle planes may be seen in its statement that " a large part of the next

six months will be consumed in getting from Europe designs of airplanes and engines, assigning them to factories, and getting production started."

Just at this time the patent situation became very alarming. On December 18, 1916, the Wright-Martin Company, as purchasers of the Wright brothers' original patent at a cost of $1,000,000, had notified all manufacturers that their patents were being infringed, and had enclosed a form of license for their use, requiring a five per cent. royalty on all airplanes built, with a minimum annual payment of $10,000. The result was "a general demoralization of the whole trade," according to a letter from the Navy Department to the National Advisory Committee for Aeronautics, as the fear of litigation had caused some manufacturers to stop all development and others to jump their prices $1,000 a plane.

The National Advisory Committee, after a series of conferences with the manufacturers, drew up a plan, approved by the President and incorporated in the Naval Appropriation bill for 1918, for the appropriation of $1,000,000 for the purchase by the Government of the basic airplane patents. In its stead, however, to remove at one sweep all the vexing questions involved in the purchase or condemnation of patents, a different plan was proposed by the Committee on March 22, 1917. Under this scheme all manufacturers so desiring were admitted to a newly formed Aircraft Manufacturers' Association, which was to be the possessor of all patents of its members. Each member was to pay to the Treasury a $200 royalty on each plane sold by it, $135 of which was to go to the Wright-Martin Company as holders of the Wright patents

and $40 to Curtiss as holder of the Curtiss patents; neither company, it was later agreed, was to receive more than a maximum of $2,000,000 before their patents ran out. The balance of $25 was to go to the Association for development and further patents.

This agreement was later bitterly criticized as forming a trust or an aircraft pool. The Attorney-General ruled, however, that it was not monopolistic because the Association was open to all. Undoubtedly the agreement put an immediate end to a situation that was threatening the whole aviation development, and, whether the price be considered high or low, it solved a most complicated legal problem in an absolutely direct manner. The Signal Corps and the Aircraft Production Board, it should be observed, have been erroneously charged with evolving this agreement.

Meanwhile, the problem of securing aviators, of organizing the complicated courses of training, and of constructing the great flying fields was becoming increasingly important. Here again a tremendous development at emergency speed in a field practically new was called for. Just what it was can be appreciated only by a bird's-eye view of the situation at that time.

At the outbreak of war the United States had but two small flying fields, that at San Diego, operated in a modest way since 1912, and that at Mineola, Long Island, just recently opened. The grand total of students enrolled was 85, which certainly did not promise a great aerial army. Fourteen civilian and no reserve military aviator instructors were available as a teaching force. The equipment at the fields consisted of 51 primary training planes, four advanced

training planes, nine motor trucks, eight motor cycles and three automobiles. The whole Aviation Section consisted of 65 officers and 1,120 men. This represented the groundwork upon which it was necessary to erect the development called for. It is not too much to say that in practical terms the United States at the outbreak of the war had almost no aviation facilities, for be it always remembered that what equipment there was on hand was several years behind the rapid development in Europe. Just as there was no one here who had ever seen a battle plane, so no one here had any idea of the intricacies of training required to turn out a pilot.

Obviously the first step was to gather what experience was available from the Allies. Accordingly, Colonel Bennett, Major Foulois and Captain Waldon visited the Canadian fields at Toronto, where to a certain degree a large-scale training had been put into effect on the most approved British plan. Merely a glance sufficed to show that the United States must replace its present go-as-you-please individual training with a standardized system carefully worked out along broad lines.

Again, as illustrative of the informal way in which everyone in those early days of the war stepped into any breach that happened to be apparent, it was the National Advisory Committee for Aeronautics rather than the War Department which took the first steps to initiate this system. On April 23, at a meeting which included besides the Committee such unexpected elements as the Secretary of the Interior and civilian members of the Council of National Defense, the Canadian procedure was informally discussed and a

complete programme laid down for its adoption here. A week later, on April 30, a more formal meeting was held with represenatives of the six scientific schools chosen to carry on the work — Massachusetts Institute of Technology, Cornell University, Ohio State University, University of Texas and University of California. The plan proposed was for the establishment of cadet courses for the preliminary training of aviators at each institution, under military regulations but with all the facilities and the teaching staffs of the colleges available at a fair rate of compensation. The chosen institutions at once agreed to the proposal and to the sending of three representatives each to Toronto by May 7.

Meanwhile, on April 30 General Squier had wired Professor Hiram Bingham of Yale, who was at the moment learning to fly at Miami, Florida, asking if he would assist in organizing this primary training on a comprehensive scale. Bingham accepted at once, went on to Toronto *via* Washington, and with 18 university representatives made as complete a study of the British preliminary training as was possible in the time available. On May 10 he wired General Squier that he could graduate the first class of 120 men from the American schools on July 14 after an eight weeks' course.

On May 14 Bingham, now a major, returned to Washington to an office where piles of books and maps served as desks, while the university representatives went back to their respective institutions to make ready the cots, bedding, books and other special facilities needed. This plan, so quickly put into effect by the Air Service, was formally approved by Secretary

Baker on May 19, and the six schools opened two days later with no definite curriculum except instructions to give three weeks of intensive military training while the other details were being prepared. Thus the "ground schools" come into being as the first step in the large-scale training of American aviators, as a result of the informal coöperation of the Signal Corps, the National Advisory Committee, the Canadian Government, and six American colleges. As against the 85 students at the outbreak of war, they provided almost at once for 200 men a week, who were very easily secured from the long list of applicants on hand ever since it was known that aviation was to play a large part in the war. On July 14 the first class was graduated exactly as promised, except that it had 147 instead of 120 members.

In the meantime the more time-consuming work of selection and construction of the new flying fields was under way. On the same day that the college presidents met to discuss the ground schools, Major Foulois and Captain C. G. Edgar were ordered to make a tour of inspection of the Middle West in search of sites. They reported on May 11, and on the 15th authority was asked of the Secretary of War to establish fields at Dayton, Ohio, Rantoul, Illinois, and Detroit, Michigan. The proposal was endorsed by the Aircraft Production Board as "a wise and necessary action;" it was formally approved by Acting Chief of Staff Bliss on May 16, and returned to the Aviation Section on May 21 to be carried out.

Everything meanwhile had been made ready to begin work. Standard plans were evolved for flying fields, hangars, barracks, etc., through visits to

Toronto and conversations with the British and French officers who were just then arriving in Washington from the front. Work was started by the contractors merely on the strength of a letter that a contract was being prepared, and, as a matter of fact, the fields were practically completed before the contracts were actually signed. Work on the four-squadron Wilbur Wright Field at Dayton began on May 27, and on the two-squadron Chanute Field at Rantoul on May 31, under the stimulus of the prospect that the first ground-school graduates would be ready for their flying instruction on July 14. Fields were selected, rented, cleared of woods and leveled, great hangars and other buildings were erected and roads and railroads built in such quick time that when this first class left the colleges they were able to go direct to the new fields for the second step in instruction.

During the first six weeks of war, therefore, a small but strong foundation was being laid to meet the aerial programme approved by the General Staff as a balanced branch of a many-sided military establishment. The beginnings of the enormous industrial development later required came with the creation of the Aircraft Production Board, and the groundwork for a large-scale training system was built with the establishment of the ground schools and the new flying fields. Moreover, the development of the Liberty motor was begun and other individual steps were taken, especially in organization. Compared, however, with what was to come later, this beginning was small indeed, and it was by no means so powerfully promoted as it would have been if the real needs had been foreseen.

CHAPTER IV

THE COMING OF THE FOREIGN MISSIONS

Arrival of the British and French War Missions — Their effect on the aviation programme — The military situation in Europe — Mastery of the air with the Germans — Inventory of America's aviation resources — Relative human and material resources of the Allies — American flying school at Issoudun, France, authorized — First aviation detachments for overseas service — Training in French schools authorized — Training arrangements with Canada, Great Britain and Italy — American technical mission sent to Europe — Its purposes and services — Premier Ribot's appeal to America — Its translation into a new and immensely expanded aviation programme — The new programme compared with the French Air Service — Opposition of the General Staff — The programme sent to Congress by Secretary Baker without its endorsement — The bill in the Committee on Military Affairs — Supporting statement of the Signal Corps — The bill reported.

Then came to Washington the British and French War Missions, Great Britain's, headed by Foreign Secretary Arthur James Balfour, on April 22, and France's, headed by former Minister of Justice Réné Viviani and Marshal Joffre, victor of the Marne, three days later. Through them Washington first came to actual grips with the war. Previously there had been all the shock of entering on a wholly new path and all the indecision and uncertainty as to how to see it through. The Missions, however, straight from the battle front, provided definite answers for every question, and brought the general war confusion down to a hard, cold analysis of facts. In short order the revolutionary principle of conscription was accepted, and all the haze surrounding the question of sending troops to France dissolved before Marshal Joffre's appeal.

In aviation more than anywhere else was the effect of the Missions revolutionary. Both had come with very strong aviation representatives, the French with Major Tulasne and Captain de la Grange, and the British with Lieutenant-Colonel Rees, credited with routing single-handed 10 German aviators. Both Missions felt free to make a strong appeal for the Air Service, not only because the only Americans they had seen in action were the Lafayette Escadrille fliers,[1]

[1] Long before the United States entered the war, this intrepid band carried the Stars and Stripes in the air at the front in France. The idea of an aero squadron composed exclusively of Americans to join the French Army was conceived originally by Norman Prince, one of America's pioneer aviators, and one of the hundreds of Americans who hastened in the early days of the war to offer their services to France in her hour of need. Prince arrived in France in January, 1915, and within two months had obtained permission of the French Government to organize an American squadron of six pilots, all with previous flying experience. Delays in training, accidents, and other causes, however, disrupted this early organization (composed of Prince, Frazier Curtis, Elliott C. Cowdin, Bert Hall, James Bach, and Andrew Ruel) almost as soon as formed, and it was not until May, 1916, that the American squadron was finally mobilized on the Alsatian front under two French officers, Captain Thenault and Lieutenant de Laage de Mieux. The seven original members of the Lafayette Escadrille, drawn from the Foreign Legion, the French Air Service, and the American Ambulance Service, were Norman Prince, William Thaw, Victor Chapman, Kiffin Rockwell, Bert Hall, Elliott C. Cowdin, and James W. McConnell. After a brief period of service in Alsace, the squadron was transferred to the Verdun sector, where it was joined by Raoul Lufbery, Dudley Hill, Lawrence Rumsey, and many other well known figures in American aviation. By the end of 1917 a total of 325 men had joined the Lafayette Escadrille, of whom some 25 had been killed, several had been wounded, and several were prisoners. Of the original seven, Prince, Chapman, Rockwell, and McConnell all gave their lives gloriously under the Lafayette colors, as did also Lieutenant de Laage. The only surviving member of the original squadron left at the front at the termination of hostilities was William Thaw, then a lientenant-colonel in the American Air Service.

but even more because they sensed the fact that the imaginative appeal of air fighting would prove the best basis for asking American aid without seeming to be endeavoring to push us into the maelstrom. From the moment of their arrival the aviation programme began to gather speed, until shortly it had completely outstripped all the plans laid down for it by the General Staff. It cannot be too clearly understood that not until the arrival of the Missions did the subsequent large programme come into consideration.

Just at this time the aerial situation abroad was very serious. On May 4 was received through the Chief of Staff the following alarming review from an American Army observer on the other side:

> At the present moment the Germans apparently have the mastery of the air. This is due to the fact that they have the superior machine. The English and French are struggling hard and suffering very severe losses. An eyewitness has just described to me witnessing the feats of the new German machines, which are small and wonderfully handy, and can describe circles around the British machines. He saw one German machine pass along the whole British line, fired at by anti-aircraft guns so that it seemed to be surrounded by the bursting shell, but escaping without damage. He saw a German machine dart down from the clouds to attack a sausage balloon, but the anti-aircraft guns instantly put a barrage entirely around the balloon, and thus saved it from destruction.
>
> Sir David Henderson told me today that they are sending over to France as rapidly as possible a new type machine which he thinks will enable them to cope with the Germans. Incidentally, I may say that Sir David Henderson has put me in touch with experts of the Air Board who will recommend to me the types of machines and engines which they think we should adopt.

COVERING THE WINGS WITH FABRIC, DAYTON-WRIGHT AIRPLANE COMPANY, PLANT 1

"DOPING" THE WINGS, THE TREATMENT FOR WATERPROOFING THE WING FABRIC AND MAKING IT NON-INFLAMMABLE

The Allied representatives in Washington in these circumstances were very anxious to know exactly how much aid the United States could give towards reacquiring the supremacy of the air. A complete inventory of America's strength as of May 11 was therefore prepared, which gives some very interesting figures. The United States at the time had 66 junior military aviators, of whom 23 were as highly trained as was possible with the lack of facilities here, and of whom the rest had had over one-half year's experience. There were also 34 civilian or reserve military aviators and 26 Army officers and 213 civilians under instruction at two Government schools at San Diego and Mineola, and at two civilian schools at Newport News and Miami. Three to four thousand applicants were already listed, and the number of mechanics, photographers, etc., was "unlimited." Nine new schools were contemplated, with a capacity of 75 to 100 men each, and with further additions to the number a total of 22 should be reached at the end of two years. Three hundred planes were in use and 2,000 to 3,000 expected soon.

Obviously America possessed enormously more human than material resources in aviation. The Allies, on the other hand, had run short of good flying personnel through the terrible drain of the first two and a half years of war, but they had a well developed system of training. It was clear, therefore, that the resources of the two could be most advantageously dovetailed, and on May 8 Major Tulasne submitted to General Squier a memorandum suggesting the establishment of an American advanced flying school in France. The United States was to furnish 200 work-

men to erect it and "all the tools, nails and other implements necessary," including a narrow-gauge railroad, while France was to furnish the planes, motors and suitably cleared land. American pilots were to begin training about July 1 and be ready to engage in battle in the fall.

This proposal was transmitted to the Secretary of War for approval on May 10, with full details of an estimated cost of $773,500 and of a weight of materials to be shipped of 16,500 tons. On the 19th it was returned rejected, but on the same day it was sent back again with the additional argument that such a field would be essential for the aviation unit to accompany General Pershing. This time it was approved, and on May 27 the first detachment of aviation enlisted men for overseas service, 200 in number, was ordered formed at Fort Sam Houston, Texas. On June 15 they were ordered to New York, and July 6 directed to proceed abroad "on the first available transportation," sailing on July 18 under the command of Captain Lawrence S. Churchill. Two days before three ships had left Hoboken loaded with materials for the school, which had been selected, gathered and put on board in five weeks time. On September 15 the school opened at Issoudun, France.

This, however, was but a beginning in the number of men to be trained. Major Tulasne on May 11 submitted another project to send 100 pilots, 500 mechanics and 500 enlisted men to France by July 1, as suggested by the French Minister of War on May 7, all these men to go to French schools. Decision on this proposal was delayed, pending determination of the plan for the American school in France. On June 12,

however, Major R. C. Bolling, former general counsel of the United States Steel Corporation and organizer of the country's first National Guard Aero Company in the spring of 1915, suggested for inclusion in this group 10 officers of that unit at New York who had had 50 hours' flying. Permission to send these men was requested two days later, and on the 15th Captain Frank Page suggested the sending of 60 members of the first class at the ground schools. On the 16th authority was asked of the Secretary of War to send the 10 officers and the 60 cadets, and on the 26th the request was repeated as the result of a very urgent cable from Bolling, now a colonel in France, advising the training of the greatest possible number of pilots and mechanicians in French schools. On July 2 the War College approved, and on July 6 the Secretary of War. Assembly of this first overseas cadet detachment began on the 11th, and on the 14th (Bastile Day) orders came for them to sail on the first available transport, under command of Captain J. E. Miller, later killed in action.

Meanwhile, also, plans were laid to send detachments to Canada. American officers had been deeply impressed with what they had seen there, and on April 30, almost as soon as the British Mission arrived, they proposed to General Bridges the sending of 50 cadets and 200 mechanics. This was approved in London on May 6, and resulted in the reciprocal training agreement which was later expanded with such great advantage to both nations.

These arrangements, entered into with considerable rapidity, considering the difficulty of negotiations between new allies and the press of other more funda-

mental issues, proved of the greatest aid to the United States. The opportunities opened for training abroad were greatly widened in the next few weeks and became a major part of America's aerial preparation. England, which nine days after the United States entered the war had asked for 50 "ferry pilots" to take planes back and forth across the Channel, opened her training facilities to American cadets, as did also Italy on the arrival of her Mission here. Thus by the fall Americans were under instruction in France, Italy, England and Canada in numbers greatly in excess of what could have been possible here and on a plan which, despite very sharp disappointments, greatly increased America's aerial strength.

Another immediate result of this touch with the front through the foreign Missions was the sending to Europe of an American technical mission composed of three Army officers, two Navy officers and two civilians. Captain Waldon on May 2 had outlined the situation to General Squier as follows:

> A month ago we were considering a commission to Europe to investigate airplane designs and airplane engines. The matter was dropped at your suggestion on account of the coming of the English and French commissions. We have had many conferences with the English representatives. All of their information, however, is second-hand and not as valuable as it would be could Captain Clark, for instance, have opportunity of collecting it on the ground.

On May 15 the Aircraft Production Board approved General Squier's resolution that this mission be sent to England and France as suggested by the British Air Board. R. C. Bolling was selected as the head of the mission, commissioned a colonel, and on June 13 was

given a general letter of introduction by Secretary Baker, authorizing him "to arrange with the allied Air Services regarding a joint programme for the construction of airplanes and engines and other means whereby the allied nations might render mutual assistance to each other in any industrial aspects of the aeronautical situation."

That this mission did not sail till June 17 is one of the vital facts in regard to the American aerial programme. The United States, wholly without technical information and disappointed in its hope of securing sufficient data from the British and French Missions, sent its own representatives to Europe two and a half months after the outbreak of war. That delay, although wholly natural in all the rush and uncertainty of the early work, held up American preparations by just that much.

As soon as Colonel Bolling[1] arrived in Europe, progress rapidly gathered speed. Quick decisions were reached on the types of planes to be built here, and models and plans were sent across; underlying business principles as to royalties and the allocation of raw materials, such as linen and spruce, were arrived at; the programme of training cadets overseas was greatly broadened; and by and large the human and the material potentialities of the United States were linked

[1] Colonel Bolling later met a tragic end, the first American colonel to give his life in France. During the great German sweep forward against the British, he lost his way in his automobile near Amiens and was killed on March 29, 1918, on the road between Estrées and Foucaucourt. In gratitude for all he had done for American aviation since he organized the first Aero Company of the National Guard in 1915 at New York, a flying field just outside Washington was later named for him.

up with the technical knowledge and battle-front experience of the Allies.

But, to return to the early American development, the greatest card of all remained to be played. On May 26 the United States Government received from Premier Ribot of France the following cablegram, terse and simple-appearing:

> It is desired that in order to coöperate with the French Aeronautics, the American Government should adopt the following programme: the formation of a flying corps of 4,500 airplanes — personnel and material included — to be sent to the French front during the campaign of 1918. The total number of pilots, including reserve, should be of 5,000 and 50,000 mechanicians.
>
> Two thousand planes should be constructed each month, as well as 4,000 engines, by the American factories. That is to say, that during the six first months of 1918, 16,500 planes (of the last type) and 30,000 engines will have to be built.
>
> The French Government is anxious to know if the American Government accepts this proposition, which would allow the Allies to win the supremacy of the air.

These few sentences laid the foundation of aviation as it exists in the United States today. They completely shattered all previous American plans and set in motion the machinery for an expansion unprecedented in history. Undoubtedly they form one of the great landmarks of America's participation in the war, comprising as they do the first appreciable appeal for aid by the Allies.

The task of amplifying these broad figures into a detailed programme was entrusted to Major Foulois, a pioneer aviator who had run away from home to enlist in the Army and who had been Wright's first

cross-country flier. Conferences were held day and night, charts, tables and schedules drawn up, and all the details of an enormous development fitted together. Every effort was made to have the figures watertight. But with no experience to serve as a guide, the whole project was new and unfamiliar, and much of it had to be drafted in the dark and under the highest pressure of time. There was neither opportunity nor knowledge for balancing and adjusting; the one thought was the supreme opportunity and the supreme need for haste.

The final figures were astounding in those days of limited aviation activities. Whereas the Government possessed less than 300 planes, the new programme called for 22,625, including 12,000 of types never even seen here. Whereas, in all the years before the war, not $16,000,000 had been appropriated for aviation, over $700,000,000 was now called for. Twenty-four new flying fields to train 1,000 men a month, as well as parks, supply depots, machine shops and fields in France, were needed.

France's request to have 4,500 American pilots in France by the following spring was worked out in detail. Beginning in August, 1917, with 540 graduates, pilots were to be turned out from the primary training schools to the number of 4,650 by May 15 and 6,210 by July 15, 1918. On January 1, 1918, advanced training was to begin on 2,500 De Haviland-4 planes and high-speed training on 800 each of the SE-5, Sopwith and Spad types. "It is entirely within our ability," reads the official summary, "to meet the request of France, provided immediate action is taken toward building the 500 primary training machines

necessary." Beyond this total of 4,900 primary, advanced and fighting planes, 12,000 service planes and 24,000 service engines were called for by June 30, 1918, including 6,667 fighting airplanes, 4,000 reconnaissance and artillery-control planes, and 1,333 bombers. The exact types were unspecified as yet owing to lack of information from abroad, but no doubt was expressed that the figures could be lived up to.

The best way to estimate just how difficult a programme France had placed before this country is to examine France's own aviation figures. Data obtained from their Mission showed that "the French have now 1,700 airplanes on the front and they are doing their best to increase this number to 2,600. They have 3,000 training planes behind the lines." The United States, therefore, was asked to develop in one year, from practically nothing, an aerial force three times the size of that which France had developed in three years of bitter warfare.

The drawing up of the programme merely marked the beginning of the difficulties. As yet, it must be remembered, the project lay entirely within the Signal Corps. Obviously, it was going to require extreme measures to secure the endorsement of both the General Staff and of Congress, for neither had been in the slightest degree prepared for a project so large, and both had good reasons for opposing it. It was fully realized that the military authorities, who regarded aviation as but one part of the military establishment, would not appreciate a programme which virtually erected the Air Service into a third arm not incomparable with the Army and the Navy themselves,

and allowed it not only to play its minor part on the American front, but to become a great international striking force. At that time nearly all line officers felt that the Service was wholly unjustified in its claims by any experience abroad.

The opposition expected from the General Staff was fully encountered. Quite apart from its anticipated skepticism, the General Staff was simply smothered in work. The whole American military establishment was in upheaval, as the foreign Missions had completely revolutionized America's plans for leisurely, rather small-scale preparation, and had brought about a general reconstruction, sending American troops abroad six months ahead of schedule. Aviation, naturally, could be considered only as an incident. The General Staff, moreover, had at that time to consider not only the military, but also the industrial phases of the problems confronting them. Real alarm was expressed by Brigadier-General Joseph E. Kuhn, Assistant Chief of Staff, lest this great aviation programme should dislocate the other more vital phases of war preparation. A detailed correspondence with Mr. Coffin and with the General Munitions Board, however, reassured him on this score, and secured a clearance for the programme so far as its industrial side was concerned.

Meanwhile invaluable time was being lost. General Squier, chafing under the delay, went directly to Secretary Baker, saying that he felt sure he could get the bill through Congress if he could once get it introduced. Thereupon the Secretary took the unprecedented step of sending the bill to Congress without formal action on it by the General Staff, but with his

personal endorsement as head of the War Department. This summary action, believed unavoidable in the avalanche of work at that time, was criticized later in Congress, but without effect. In a sense the Air Service had now broken out from the general military establishment; it was henceforth to run its own course, until a year later its programme was shown to have been impossible.

As public opinion was being prepared on a scale never before attempted by a Government agency, the final bill was put into the hands of Chairman Dent of the House Committee on Military Affairs on July 4. Here also another precedent was broken, which was later criticized in Congress, in that the bill, carrying an appropriation of nearly two-thirds of a billion dollars, was presented to the Committee on Military Affairs rather than to the Committee on Appropriations. The bill was introduced in the House on the 6th, though without any intimation of the amount of money involved in the appropriation, and was referred back immediately to the Committee on Military Affairs.

The Committee held exactly two meetings with War Department officials. Despite early consternation at the size of the programme, the essential logic of its presentation, the romance of aviation itself, and the wide publicity already secured created a very favorable atmosphere. General Squier and Major Foulois carried the first meeting. General Squier's statement, written around Premier Ribot's cablegram, so well shows the attitude at the time, the confidence of execution, the appeal for haste, and the pressure on Congress, that it is here given in full:

The foregoing cablegram is based on military necessity, and from a military point of view, is conclusive and without question.

The French Government, without doubt, urgently needs vital assistance from the United States before the spring campaign of 1918.

We can produce, in the United States, the 5,000 pilots and 50,000 mechanicians by May 15, 1918, *provided* the funds are forthcoming for the manufacture and purchase of *training machines* heretofore mentioned.

We cannot produce or provide the necessary *service airplanes* and *engines* for these 5,000 pilots unless funds are also immediately forthcoming for their manufacture and purchase.

The *estimate* for *service airplanes* and *engines* is based upon the cablegram from the Premier of France, in which he states that this country should construct 2,000 airplanes and 4,000 engines each month. Based upon this figure there should be produced, by the United States, 12,000 airplanes and 24,000 engines during the period January 1, 1918, to June 30, 1918.

It is my opinion, that the Premier of France is fully cognizant of the military needs of this country, and would not make such an important request unless he believed it of absolute military importance to the cause of the Allies.

It is further my personal opinion, that a country, which has been carrying the burden of the greatest war in history, is fully cognizant of the enormous military value of airplanes in actual war, and when that country asks the United States to assist in maintaining the supremacy of the air by the utilization of its enormous wealth and resources, I do not believe that any official, military or civil, in this country, is in a position to say that such assistance should be withheld, unless this country intends to act in a perfunctory manner in its coöperation with its Allies in war.

I, therefore, urgently recommend that the estimates, as submitted, be approved, in order that this country may be in a position to render valuable and necessary assistance, to its Allies, with the least delay.

The second meeting of the Committee was with the foreign aviation officers who had come over direct from the battle front with the Missions. Colonel Rees, Major Tulasne, Captain de la Grange and others all told of their actual experiences at the front and supported the American officers' claims in every way. Their presence was most stimulating, as it was the first time officers of the Allied armies had appeared before a Congressional Committee.

Every fact and figure in the possession of the Signal Corps was supplied to the Committee, but naturally on a project so new and unfamiliar the discussion had to deal largely in estimates and approximations. If it be said that the whole attitude was over-optimistic, it may be answered that the aviation officials were gambling for enormous stakes at the request of the Premier of France, and that if they had not been utterly fearless themselves, they could never have ventured forth on such a programme.

In record time the bill was rushed through the Committee, and on June 13, a week after its receipt from the House, it was reported unanimously. Only one amendment of any importance was made by Chairman Dent's Committee, that of adding Section 10:

> That for the purpose of carrying this Act into effect the sum of $640,000,000 is hereby appropriated.

The report concludes:

> The report of the Committee is unanimous. Expedition in the passage of the bill was considered also of the utmost importance. English, French and Italian officers appeared before the Committee in addition to our own and all concurred in the conclusion that the control of the air was at this time at least the most important thing that could be

done. In fact it was boldly stated that the control of the air would naturally result in reducing to a large extent the number of men necessary in the trenches.

For the reasons above stated the Committee unanimously and earnestly urge the passage of this bill.

CHAPTER V

THE ADOPTION OF THE NEW PROGRAMME

The campaign for public and Congressional sanction — Publicity methods of the Aircraft Production Board — The press enlisted in support of the programme — Public statements of Mr. Coffin, General Squier, Secretary Baker, and President Wilson — Extent of editorial support — Effect on public opinion of the publicity campaign — The bill in Congress — The debate in the House — Mr. Mann's speech — Debate limited to an hour and a half — The bill passed without amendment and without roll call — The debate in the Senate — Final passage and enactment — The programme launched — The seeds of later disappointment sown in the optimism of the early publicity.

The great task of securing public and Congressional approval for this unprecedented programme now remained, and the campaign through which it was accomplished forms one of the most extraordinary chapters both in governmental and in American legislative history. Obviously, $640,000,000 could not be asked for in those days of small appropriations, and still smaller knowledge of aviation, without a very special preparation of the public mind. The step was so startling, even to those close to it, that it was fully realized that the way must be carefully prepared.

Fortunately the time was fully ripe. Aviation had been born in this country, possessed a romantic appeal to the American imagination, and had been the most fully reported phase of the then distant struggle, especially because of the famous Lafayette Escadrille. The Air Service was uppermost in the minds of newspaper correspondents and of the public, and both were

eager for all information possible. Moreover, the Service, through its very newness and its civilian personnel in the Aircraft Production Board, was very responsive. Already, even before the big programme was drawn up, there had been considerable publicity, and on May 21, Mr. Coffin had made "the first authoritative statement of America's war policy in the air," showing that at that time 3,500 planes, including both training and battle planes, was the limit contemplated six weeks after the declaration of war.

For the next two weeks the situation remained unchanged to outside view, while within the War Department the French cablegram was being amplified into the big programme. On June 2 Mr. Coffin issued a somewhat more insistent statement:

> France and Great Britain have made it plain again and again that they expect aircraft and aviators to be one of America's greatest contributions to success in the war. America is responsible for the intention of both the submarine and the airplane. In the development of both she has allowed Europe to outstrip her. It is for us to show that we can yet surpass both our enemy and our Allies in the development of the two great mechanical inventions for which we ourselves are responsible.

Mr. Coffin, however, had no illusions about the industrial difficulties of supplying planes for the 500 cadets who were to begin flying instruction on July 20. "It is just possible," he said, "we cannot get a full equipment of airplanes within the time, but we shall have enough to get a part of the men in the air, and shall not be seriously handicapped the first few weeks if we do not have our full quota."

A great change in publicity methods had now come

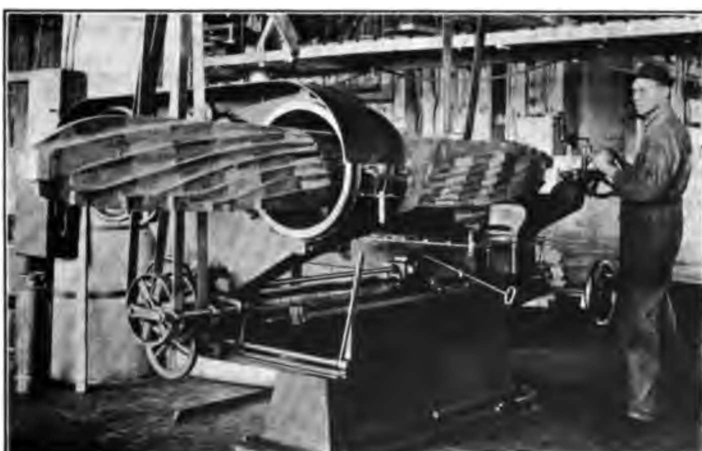
with the final working out of the details of the new programme. Aggressiveness was needed, first, to make the appropriation at all possible, and second, to put it through at emergency speed. Accordingly, a confidential luncheon was held in New York on June 8, at which were a score of the most powerful editors of the United States. Its purpose was frankly confessed by Mr. Coffin:

> Gentlemen, if you agree with the logic of the statements which I am making to you today, it will lie within the power of the comparatively small group of men here in this room to do more towards the passage of this bill through Congress, to do more to carry this programme to a successful conclusion, than can be accomplished by any other agency in this country. The future history of the world's nations may be influenced by your action.

Grosvenor B. Clarkson, Secretary of the Council of National Defense, who presided, was equally frank in his statement that "this story is surely coming down to the question of the people of the country calling for and getting behind and pushing the bill, perhaps for a startling sum, that will be presented to Congress to bring into being a sufficient Air Service." The hope was not so much to secure immediate publicity as to lay a groundwork in the minds of the men there present that would be receptive for the announcements shortly to come from Washington. Editorial discussion was very much desired, and the statement was made by Mr. Coffin that "a smashing series of news stories" on aviation matters were in prospect.

Mr. Coffin promised a means "to help the foreign situation and help it immediately, certainly within 90

EXPERT WELDING ON CAPRONI FITTINGS, STANDARD AERO CORPORATION



ROUGHING OUT THE DE HAVILAND-4 PROPELLER

days or four months at the outside." He summarized the situation as follows:

Now, if we can do this thing, and beginning with the first of January, start sending air men to Europe for finished training on the European fields with the fast types of machines, we will have done more to make a dent in this great struggle in which we are involved on the other side of the water than we can in feeding any number of troops of the line into that maelstrom on the western front. If the United States can, as its contribution to the cause of democracy, give to the Allied forces the supremacy of the air and can maintain that supremacy for the duration of the war, I think we may take it for granted that the length of the war will be very much shortened and the lives of hundreds of thousands of Americans and of all other nationalities saved.

We have seen Germany repeatedly shift a million of the finest troops in the world from the east to the west fronts without even making a dent in the Allied line. Mere numbers of men count little in this great struggle. The land may be trenched and mined; guns and bayonets form an impossible barrier. The sea may be mined and netted and the submarine lurks in its depths. But the highways of the air are free lanes, unconquered as yet by any nation. America's great opportunity lies before her. The road to Berlin lies through the air. The eagle must end this war.

Mr. Deeds, in a similar speech, said: "If we start immediately, we can put 10,000 aviators on the French front by this time next year and win the war. We are convinced of this. If we can put through the programme as provided in the bill, soon to be introduced to Congress, we will get over there next spring in time to win." Major R. C. Bolling, in urging the vital necessity for speed, said that "every day lost in supporting this thing, every day lost in bringing our full forces to bear, means three or four thousand more

Americans that will not come back at all, or will come back crippled and of no use at all. That is what we are facing—time—and first of all time." The British and French aviators who had already been so influential with Congress were also called upon. Colonel Rees gave a graphic story of the romance of air fighting, and Captain de la Grange stated that the Battle of the Marne had been won by airplanes reporting the huge concentration in Belgium, and predicted that if America put her whole heart into aviation, "before next Spring we will put out the eyes of the beast before we try to kill it."

This meeting had a tremendous effect. Editorials began to appear all over the country, all demanding, first, a huge air fleet, and second, all speed in Congress. Later, when the promised announcements came forth from Washington, they were given the very best possible display in the press and were often accompanied by editorial support. At this time also the Aero Club of America, which long had been urging aerial preparation, and which had endorsed previous official statements, came out on July 9, through a letter from its President, Allen R. Hawley, to Chairmen Dent and Chamberlain of the House and Senate Committees on Military Affairs, for an appropriation of half a billion dollars to supply 40,000 planes and 10,000 aviators. "This may seem and is large, but it seems to be the most economical way of striking Germany."

On June 14 Mr. Coffin sounded the opening call of a series of public statements in a forceful announcement that the American people "must be prepared to enter the war in the air to an extent hitherto unheard of if their power is to have any effect on the result

of the war during the next year." The American authorities had been informed by the Allies that if airplanes and aviators commensurate with the country's resources were supplied immediately, a greater contribution to the success of the Allied cause would be made than by the sacrifice of thousands of American lives in the trenches later on. Two days later General Squier issued a public appeal to

> put the Yankee punch into the war by building an army in the air, regiments and brigades of winged cavalry mounted on gas-driven flying horses. . . . $600,000,000 is negligible against the certainty of victory thus offered. . . . Sweep the Germans from the sky, blind the Prussian cannon, and the time will be ripe to release an enormous number of flying fighters to raid and destroy military camps, ammunition depots, military establishments of all kinds.

A dispatch form Paris that Germany intended to bring 3,500 planes into action in 1918 offered Mr. Coffin the opportunity to issue another statement:

> Our plan contemplates nothing less than driving the German fliers out of the air and maintaining a constant raiding patrol over the territory for fifty miles back of the fighting lines. If we build the quantities of machines for which we have the capacity and train our thousands of available men, we can tear up the enemy communication lines and prevent the movement of troops and supplies.

Immediately afterwards Secretary Baker, on June 18, issued a statement that "the War Department is behind the aircraft plans with every ounce of energy and enthusiasm at its command." An air service, he said, could be trained, equipped and transported more quickly than infantry or artillery and at the

same time be proportionally more effective. Aviation "furnishes our supreme opportunity for immediate service, and may spell the whole difference between victory and defeat." Aerial domination must be secured for the Allies during the year.

On June 21 the Aircraft Production Board stated that it would attempt to standardize airplane manufacture along somewhat the same lines, though obviously not to the same degree, that automobiles had been standardized. At the same time the announcement was made that speed scout machines would not be made here because of the distance from the front, and information was allowed to escape that 2,000 engines would be delivered monthly, beginning in November of 1917.

Then, with the bill actually presented to Congress, President Wilson himself was called upon. On June 23 the following letter to Secretary Baker was published:

> I have your letter of yesterday about the production of aircraft and the training of men to operate them, and want to say that I am entirely willing to back up such a programme as you suggest. I hope that you will present it in the strongest possible way to the proper committees of the Congress.

On the same day Orville Wright, who had been put in charge of the great Government flying field at Dayton, where he and his brother made their first experiments, issued a statement in Washington:

> If the Allied armies are equipped with such a number of airplanes as to keep the enemy planes entirely back of the lines so that they are unable to direct gunfire or observe the movements of the Allied troops — in other words, if the

enemy's eyes can be put out — it will be possible to end the war. This is not taking into account what might be done by bombing German sources of ammunition supplies such as Essen, which is only 150 miles behind the fighting lines.

Meantime much individual publicity was being had. On July 1, for instance, the *New York Times* printed two interviews, one with Orville Wright and the other with General Squier, the latter stating that "we can make the Kiel Canal itself useless" with airplanes. Dr. Joseph S. Ames, an eminent scientist, came out on the 5th for 20,000 planes and 10,000 aviators, and on the 7th reports stated that Germany would be defeated within a few months of the completion of the 22,625 planes called for in the $639,000,000 programme, which it was estimated could be turned out at the rate of 3,500 a month.

During early July also the foreign aviators here were brought into the publicity. Captain de la Grange, in a series of three interviews issued by the Committee on Public Information, pointed out the great value of aviation, the enormous strides made in Europe, and the fact that America could here give its most immediate and vital assistance. These interviews went into great detail and gave many figures, but did not convey the impression that the task was difficult. Colonel Rees, of the British Royal Flying Corps, also aided in outlining the needs of the situation.

Something of the effect of all this publicity may be seen in the series of editorials run in the *New York Times*. While this paper was one of the most consistent supporters of aviation, many others were

almost equally earnest. Its editorial page for that short period shows the following articles:

June 5: "Belated Recognition."
10: "First of All Airplanes."
15: "For Air Supremacy."
16: "Give Our Airmen a Chance."
18: "Build More Airplanes."
20: "Give Us Airplanes and Airmen."
22: "The Aeroplane Program."
26: "Call for Recruits."
July 5: "Aviation Plans Must Not Be Delayed."
8: "Get the Airplanes Ready."
9: "American Aviators Needed."
10: "Squadron Flights."
17: "Aviation Appropriation Bill."
20: "Hampering the Government."
23: "At Last the Airplanes."

Thus aviation, in an amazingly short time, was brought to the very forefront of American public attention as the quickest and least onerous method of defeating Germany It is not too much to say that when the unprecedented estimate of $640,000,000 was presented to Congress, public opinion at large stood as a solid unit not only for its enactment, but for its enactment immediately.

The bill was now before Congress. Up to the time of its presentation aviation had figured but slightly there, although there had been some discussion of a Department of Aeronautics under a civilian Secretary. Immediately after the House Committee on Military Affairs had unanimously reported the bill, on July 13, Mr. Coffin issued a statement calling the Committee's action "almost unprecedented in its promptness and thoroughness," and praising "its complete non-

partisanship or dissention of any kind," as well as the great speed with which all details had been prepared by the War Department. The great remaining need, he said, was for similar speed in the two Houses of Congress and throughout the industries.

The next day the bill was debated in the House. Chairman Dent met the only setback in the course of the appropriation when his request to limit debate to one hour was refused. His introduction was a model of brevity:

> Mr. Chairman, the report that accompanies this bill states substantially everything that I could fully and justly state on the floor of the House. This bill provides for the temporary increase of the Signal Corps, particularly the Aviation Section thereof. It is limited to the existing emergency. It authorizes the President in general terms to organize this temporary force into divisions, brigades, regiments, wings, squadrons, battalions, companies and flights. The act itself does not fix the number of any of these different organizations, but leaves that entirely to the discretion of the President. The object of that, Mr. Chairman, is readily seen. If by law Congress should undertake to fix the number of machines that will be constructed and to declare the number of men that will be employed in this temporary additional service, and all of the details with regard to the same, it would destroy the very purpose of this legislation. It would give to the enemy the very thing that the enemy ought not to know. The bill does carry a lump-sum appropriation of $640,000,000.

A desultory debate, aimed less at the matter of the bill than at several rather extraneous considerations followed. Representative Miller, for instance, said he was informed "that the War College has never passed on these details." Mr. Burnett asked if the appropriation were sufficient "to enable the Bureau to

answer letters addressed to them by members of Congress," and several members criticized the great secrecy demanded of Congress in contrast to the full publicity recently issued.

In the midst of this desultory skirmishing Republican Minority Leader Mann rose to his feet. He asked Mr. Dent for two or three minutes' time and was granted as much as he desired. His attitude as Minority Leader in a close House was pivotal. He spoke as follows:

Mr. Chairman, I have seen no information published by the Council of National Defense or in the papers either, which gave any accurate information as to what the plans were in reference to aviation. Of course the amount of the estimate was made public. The amount of the appropriation is carried in the bill. I wish it were possible for that to be concealed. With the amount of appropriation carried in the bill, it is inevitable that people will speculate as to what will be done with it, as to how it will be expended, what will be the organization of the Aviation Corps, the number of aviators, the number of machines, the character of the flying machine, and all that. But that will be speculation.

Now, as to the Army, the matters in connection with the Army are fairly well known throughout the world as to all armies. There are two new things in this war among others — in fact, there are many others beside the two — but the two which stand out prominently are, first, the submarine, through which Germany is endeavoring to starve out England, and thereby win the war, and, second, the use of flying machines of some sort for the control of the air. Those are matters of speculation. We know but little about them. If my information is correct, the men at the head on the part of our Government and the Allies know but little concerning the submarines of Germany — the number, and for that matter, the later type, although we see statements in the newspapers from time to time. I can see today no

way within the near future of starving out Germany. I can see no way in the near future of starving out the allies — England or France. I can see no way for the German Army breaking through the line into France on the west front. I can see no way for the allied army breaking through the German Army on the west front under any existing standards of warfare. But here is an unknown quantity — the use of flying machines. No one knows what can be accomplished by it. No one knows its limitations. No one knows its possibilities. Did you ever buy a pig in a poke and take chances on it? Sometimes it turns out very fortunately; sometimes with the loss of the money invested. And I believe that the time has arrived with our country when we can afford to spend an immense sum of money in trying out the control of the air [applause] and see, first, whether that will give us control of the battle front; second whether it will strike demoralization and produce revolution in Germany itself. [Applause.]

If I had my way about it, I would pass this bill without saying a word. [Loud applause, and cries of "Vote!" "Vote!"]

There has been no information yet published which will be worth much to the German Army. But every particle of information which is furnished to this House or to this Congress will find its way into the powers that control the organization of the fighting machine of Germany. And I would not give them any information until they learned it in the field. [Loud and prolonged applause, and cries of "Vote!" "Vote!"]

The effect was electrical. The House for a moment was swept off its feet. It was obvious that the bill would pass as it stood and that further debate would be but perfunctory. With cries of "Vote!" "Vote!", Mr. Dent succeeded in having the debate limited by unanimous consent to one hour and a half.

Mr. Fitzgerald (Democrat), in a long attack on the mechanics of the bill, objected that it was unconstitu-

tional because unlimited in time, that though an appropriation bill it had been sent to the Committee on Military Affairs, and that it made no provision for raising money. Mr. Miller (Republican) said: "We ought to know that it has the endorsement and approval not respecting plan alone, but detail as well, of the War College and the General Staff. Decidedly it has not so come." Mr. Gillett (Republican) censured the War Department, which "in defiance of the law, sent in no estimate, but privately asked the Military Affairs Committee for it." He believed the secrecy exaggerated, possibly "to excuse the usurpation of the Military Committee," but agreed to waive his objections "because I believe that our best chance of speedy success is to promote actively our aeroplane development."

"Delay is not justified," Mr. Thomas (Democrat) said. "I want to see this bill passed quickly, for I have confidence in the general belief that no single act can do so much towards winning a speedy victory." Mr. Wood (Republican) reiterated this belief, and Mr. Fess (Republican) said that "in the unshaken faith of American achievement I willingly vote today authority for unlimited expenditure of money to harness, through American energy, the possibilities of the air to stop this world tragedy." Said Mr. Sherley (Democrat):

I have an abiding faith in the part that warfare in the air is to play in the determination of this war. You have reached a peculiar condition in both land and sea warfare, a condition largely of stalemate. In the air you fight in three dimensions. We alone are in a position to bring into the scale great resources, and by bringing them in give such

MACHINING TOPS OF LIBERTY MOTOR CYLINDERS, PLANT OF THE NORDYKE AND MARMON COMPANY, APRIL 1918

a predominance as to unquestionably have a very marked and, I believe, a speedy determination of the issue.

The skepticism with which all great new steps in human development, such as the discovery of America, of cotton, of vaccination, etc., had been regarded, was described by Mr. Hulbert (Democrat), whose great objection to the bill was that it did not go far enough in providing a separate Department of Aeronautics. The secrecy demanded was again justified by Mr. Kahn (Republican), who severely criticized those who seemed "to be intent on going to war as if we intended to go hunting ducks with a brass band." Mr. Quin (Democrat) said: "One aeroplane is worth, according to the testimony, at least one regiment of cavalry. It is worth as much as 12,000 to 15,000 cavalrymen or private soldiers."

A phase which was in every one's mind was brought out by Mr. Gard (Democrat):

I am in favor of this bill because I think, first, the plan contained therein will win the war, and for the additional reason that it is one of war's abhorrent activities which will have a commercial residue of value. When war shall have ceased, the result of invention and industry will have been such that the development of the flying machine will be no development of hazard, sport or slaughter, but afford a new and effective means of transportation in times of peace, bringing increased efficiency and happiness to all people.

Alone of all the speakers, Mr. La Guardia (Republican) said he did not agree "with what has been said about this war being won with the airplanes we provide today. This war will be won in a much more cruel and less spectacular manner." He particularly

asked Congress not to hamper the War Department by any unnecessary restrictions or by asking favors. At this moment Mr. McKeown (Democrat), the only dissentient, offered an amendment to cut the appropriation in half, but it was immediately voted down. Chairman Dent requested a report on the bill, which was read a third time and passed without roll call. "I ask unanimous consent," Mr. Hulbert said, "that the records show that there was no member voted against the passage of the aeroplane plan." "Let the records show it," the Speaker ruled, thus passing through the House with the briefest debate the largest appropriation for a single purpose in the history of Congress.

The effect upon the public was most salutary. Seldom before had such an example of solidarity been presented. Nevertheless, rumors at once arose that the bill was to be held up in the Senate. This brought forth an outburst of editorials, which made some members of Congress charge that the bill was being railroaded through.

On July 16 the bill was reported to the Senate and referred to the Committee on Military Affairs, who reported it out the next day, without amendment, at a session lasting only 45 minutes. Senator Chamberlain, on the 18th, introduced it with the following very brief remarks:

The bill is so plain in its terms that it does not seem to me to be necessary nor advisable in the crisis which confronts our country to undertake to analyze the several sections of it or to discuss the bill at any length. It speaks for itself. The House Committee on Military Affairs entered into extensive hearings with reference to the bill, and

after the hearings it was carefully revised, reported to the House, and passed, without a dissenting vote and with very little discussion. When it came to the Senate it was at once referred to the Committee on Military Affairs, and after some discussion the Committee felt that while there was much in the measure that might just as well have been left out, yet in view of the urgency of the situation, concluded to report to the Senate without any amendment whatsoever.

The greatest objection was to the applicability of the draft provided in the bill, which was brought into question by Senators Curtis (Republican), Hardwick (Democrat) and Vardaman (Democrat); the latter stated also that the appropriation appeared "ridiculously large, but that is in keeping with the prodigality with which public moneys are being expended by Congress. It looks like a pretty heavy burden on the toiler when you realize that for this purpose, and this alone, a tax of about $30 for the head of every family of the United States is levied." A real national danger in the lack of safeguard for the money appropriated was seen by Senator Owen (Democrat), who urged a special committee for this purpose. Senator Jones (Republican) feared "the appointment of Brigadier Generals and Major Generals almost without number," while Senator Reed (Democrat) re-expressed the views of the Committee — that though some features were objectionable, "the bill ought to be passed immediately without amendment, in order to get the work under way."

On the 19th Senator Williams (Democrat) again urged haste, stating "there are two things going on now that are attracting the attention of the world — talk in the Senate and the war in Europe." On the next day Senator Owen voiced the opinion of many

other Senators in protesting against what they considered to be a steam-roller process. Finally, however, on July 21, one week after the bill had passed the House, it was passed by the Senate. Here again there was no disapproval of the main purpose of the bill, no amendment, no roll call, and debate only on very extraneous issues.

Mr. Coffin and General Squier at once met the request of the press for statements. The former said that "all world's records for industrial development of a new art must be broken," and issued a word of caution that a few months must necessarily elapse before the outward results of our industrial efforts would show in the shape of quantities of finished fighting machines. General Squier, in refusing to give out details, said that "the determination of the Allies is to enter Germany by the air route," but swift opportunism might necessitate many changes of programme to counter the moves of Germany.

On July 24, 15 weeks after the declaration of war, the great programme was launched with President Wilson's signature of the Aviation Act.[1] Its whole record so far had been extraordinary. It had required six weeks to draw up the programme, one week to put it through the House Committee on Military Affairs, one day to put it through the House, and seven days to put it through the Senate, or less than two months in all to expand the 150-word cable from the Premier of France into an appropriation of $640,000,000 establishing a new art and a new industry in the United States.

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[1] The full text of the Aviation Act of July 24, 1917, is given in Appendix I.

The sharpest criticism has centered about the early publicity and its optimism. Beyond all doubt the hopes expressed at that time were not later fulfilled, but it is only fair to take all phases of the situation into consideration — the unfamiliarity of every one concerned with the intricacies of the task, the obvious necessity for haste, and the temptation to be enthusiastic about a subject already dangerously romantic. Whatever be the grounds for criticism, the fact remains that an enormous programme was launched in wholly unprecedented time, and the great aerial army which later developed set far ahead on its long road of preparation.

CHAPTER VI

THE UPBUILDING OF THE FLYING FORCE

The situation at the passage of the Aviation Act — Limited foundations for expansion under the new programme — Aircraft Production Board personnel transferred to the Signal Corps — Equipment Division created under Colonel E. A. Deeds — Creation of the Aircraft Board — Difficulties of organization — Their reaction upon production — The problem of personnel — Impossibilities of the manufacturing programme — Advanced and primary training delayed by lack of planes — Recruitment of the flying force — Essential qualifications of military aviators — Quality of the army of volunteers — Selection of candidates — Aviation examining boards — Physical tests — Recruitment of non-flying officers — Status of flying cadets — Organization and functions of the ground schools — Their courses of instruction and services — Structures to house the air army — Location and rental of the flying fields — Their design and construction — Flying fields increased from two to 18 in the first eight months of the war — Construction overseas.

Three and a half months after the declaration of war, America's enormously enlarged aerial programme was finally launched. It is necessary to keep this date in mind, for it serves to explain what has been described as very slow progress.

Up to the signing of the Aviation Act on July 24, solid foundations had indeed been laid, but on a limited scale. The ground schools and two new flying fields had been put in operation; the Aircraft Production Board had been formed to handle what was now to appear by comparison a rather small problem; the Liberty motor had passed its first test; and there had been sent overseas a few cadets for training and a technical commission to see what a battle plane

really was. Lines of policy had been laid down, personalities adjusted, and other wholly preliminary work done.

Compared with the problem ahead, however, this beginning was not imposing. During these 15 weeks from the outbreak of war, the increase in size of the Service, for instance, had been limited. Indeed, a week after the Act was signed the personnel stood at 127 flying officers, 84 non-flying officers, 2,300 under or awaiting instruction, and 10,107 enlisted men.

Naturally the expansion first became apparent in Washington, about the Aircraft Production Board. With all the vital industrial work originating there, the Signal Corps soon found itself in the impossible position of being wholly dependent in its most critical function upon a branch committee of a Committee which was itself purely advisory. In order to remove this anomaly, Mr. Deeds and Mr. Montgomery of the Board were taken over into the Aviation Section as colonels, Mr. Cable, Secretary of the Board, as captain, and, later, Mr. Currier as major.[1] On August

[1] The Aircraft Production Board nevertheless continued to function in an advisory capacity, mainly with the same personnel. It was given a new status by Act of Congress of October 1, 1917, which created the Aircraft Board and thus defined its functions and powers:

[SEC. 1.] That for the purpose of expanding and coördinating the industrial activities relating to aircraft, or parts of aircraft, produced for any purpose in the United States, and to facilitate generally the development of air service, a board is hereby created, to be known as the Aircraft Board, hereinafter referred to as the board.

SEC. 2. That the board shall number not more than nine in all, and shall include a civilian chairman, the Chief Signal Officer of the Army, and two other officers of the Army, to be appointed by the Secretary of War; the Chief Constructor of the Navy and two other officers of the Navy, to be appointed by the Secretary of the Navy; and two additional civilian mem-

29, nearly five months after the outbreak of war, Colonel Deeds was formally placed by General Squier in charge of the Equipment Division, entrusted with producing the thousands of planes and engines necessary in a few brief months and with spending upwards of $350,000,000. Colonel Deeds was able to start at this late date with a force of only 14 officers and 111 civilians, which inside half a year grew to 300 officers and 2,700 civilians.

It is apparent from these dates and figures that no matter how well the bigger industrial work had been done in the first few months of the war, a wholly insufficient organization had been built up for the needs that were now to appear. The smallness of the original programme, the very limited ideas with which the new men called to Washington first began to work, and the lack of quick realization of what the new programme was to mean, all contributed to this slowness

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bers. The chairman and civilian members shall be appointed by the President, by and with the advice and consent of the Senate.

SEC. 3. That said board and tenure of office of the members thereof shall continue during the pleasure of the President, but not longer than six months after the present war. The civilian members of the board shall serve without compensation.

SEC. 4. That the board is hereby empowered, under the direction and control of and as authorized by the Secretary of War and the Secretary of the Navy, respectively, on behalf of the Departments of War and Navy, to supervise and direct, in accordance with the requirements prescribed or approved by the respective departments, the purchase, production, and manufacture of aircraft, engines, and all ordnance and instruments used in connection therewith, and accessories and materials therefor, including the purchase, lease, acquisition, or construction of plants for the manufacture of aircraft, engines and accessories: *Provided*, That the board may make recommendations as to contracts and their distribution in connection with the foregoing, but every contract shall be made by the already constituted authorities of the respective departments.

in organization, which in itself held up the whole development by just that length of time.

In the personnel and the training side of the Service, the expansion, though less noticeable from the outside, was very much greater because of the need for men for training, for the flying-field organizations, and for the ever increasing overseas demand. New fields, new examining boards, new schools, and new camps began to spring up all over the country in quick succession. Naturally, however, the division in charge of this work went through the same difficulties as the Equipment Division. Hardly had the various sections been formed and their duties delineated than they again outgrew their limits, and another reorganization was necessary. Officers were forced to divide and subdivide their work, to move from building to building, and to see constant shifts in administration. General Foulois, for instance, who had seen the whole organization grow from one room to nearly a whole building, left for Europe in October, and he was followed during the year by other officers who had largely put the machinery together.

Constant change, growth and development along lines very difficult to foresee thus took place, both in personnel and in equipment. Only by actual experience can one appreciate what an endless amount of time such readjustments require and how difficult it is to fit to one another new personalties, new plans and new ambitions. The time lost in developing the mechanism of organization formed one of those imponderable elements which no one had discounted in advance. The next six months, therefore, must be looked upon in a double light, as months of creating an

organization as well as months of creating aviators and planes. Obviously the two were interdependent and interacting, each delaying and holding up the other.

Wholly unexpected problems arose on all sides, for matters were being dealt with which were entirely new to everyone concerned. It was not foreseen, for instance, in the rush of other work, that the whole plane programme might be held up for lack of acetate of lime, any more than it was foreseen that difficulties abroad would more than double training difficulties here. Knowledge had to be acquired by bitter experience and disappointment, the best hopes often meeting with sharp disillusion, and fears hardly expressed often developing into realities. Meanwhile, days were slipping by into weeks and weeks into months, while still the fulfillment of the early promises always seemed just over the crest.

The only possible way to appreciate just what the first year of the Air Service was is to go straightway into the details and explore its manifold ramifications and complexities. To recreate all those new and unexpected problems will give an idea of just what work was done and what mistakes were made. It is a romance, whether it be called a success or a failure, which will bear comparison with any in the war.

To begin at the beginning, the problem of personnel for this great new aerial force, of pilots, observers, photographers, bombers, engineers, instrument repair men, and the like, opened up a wholly new field which deepened in complexity with every step taken into it. Never had this country had any experience to reveal how difficult it would be to man an aerial army, or to

PLANT OF THE FORD MOTOR COMPANY DEVOTED EXCLUSIVELY TO THE MANUFACTURE OF LIBERTY MOTORS; FIVE FLOORS, EACH 60 BY 900 FEET

indicate into how many by-ways of science and organization the work would lead. The problem was approached, therefore, without a full realization of its pitfalls. Nevertheless, it required very little imagination to realize that to train 1,000 fliers a month, at first almost without planes, fields or teachers, would necessitate a complete abandonment of the previous small-scale, free-and-easy system in use here when less than 100 men were under instruction.

Plans were drawn up on as comprehensive a scale as possible, always subject, however, to the inescapable fact that equipment lagged far behind personnel. As the work unfolded, one quick change in policy after another was adopted in an endeavor to cut corners and keep abreast of an almost impossible schedule. The programme presented to Congress with the $640,000,000 appropriation, however, barely outlived the debates, for it became evident at once that the projected number of planes could not be manufactured in the time available, especially the 2,500 De Havilands and the 2,400 Spads, Sopwiths, and SE-5's needed by January for advanced training. Just at this time the foreign Missions offered the hope of giving advanced training behind the lines abroad, and a quick change of policy was made which counted on having this training done overseas. Only too soon, however, it became apparent that the hundreds of cadets who had been sent across were likewise without planes and that America would have to solve the advanced-training problem here as well.

The problem of primary training likewise wavered back and forth. Whereas the original Congressional programme called for 540 graduates monthly in mid-

August, September and October, with 660 more by November 15, only 598, or just one-quarter of the total, were graduated by November 30. This delay was very largely traceable to the shortage of planes, for instead of 600 by August 1, 744 by October 1, 1,536 by November 1, and 1,824 by December 1, as estimated, the actual deliveries were from one-third to one-half of these figures, being 230 by August 1, 401 by October 1, 492 by November 1, and 866 by December 1. Just at this point, fortunately, a sharp corner was cut. The plan for southern schools for winter training had been adopted since the Congressional debates, and a considerable acceleration over that programme took place. Indeed, the sharp drop to 285 graduates predicted during the months from November 15 to January 15 was largely avoided.

The element of the whole air programme in which the least difficulty was experienced was in securing applicants for flying service. Despite the well advertised danger, men volunteered by thousands. Constant reports of deaths of famous aviators abroad were far outbalanced by the romance of the service and the opportunities for individuality. Aerial exploits from the very first days of August, 1914, when Garros was supposed to have crashed head foremost into a German plane to destroy it, had fired America's imagination to a forgetfulness of the dangers involved, and from July 14, 1914, to June 2, 1918, a total of 38,770 men sought admission to the Air Service as fliers. This army of volunteers appears quite extraordinary when it is realized that the whole military establishment of the United States a year before was only four times as large.

The difficulty, however, lay in securing, not enough, but the right type of men. One who is to fly three or four miles up in the air must have perfect heart and lungs; to master aerial navigation, reconnoissance, wireless, and machine gunnery he must have a clear mind; and to pick out and send down important information he must have judgment and a sense of responsibility. Many men have one, perhaps two, of these characteristics, but only a limited number have all three.

At first the quality of applicants was remarkable. Indeed, the very flower of America's youth came forward at the outbreak of war, with the feeling that trench warfare did not, after all, give a true opportunity for full expression of their ability. Three or four months later, however, the quality began to fall off, with the draining of the first enthusiasts and the attraction of other good material to the Officers' Training Camps, until in October corrective steps were necessary. Very soon the plan was proposed of securing the larger proportion of candidates from the Officers' Training Camps. This plan at first broke down, for the camp commanders, largely old line officers, turned over to the Air Service men not qualified for line work; but it was corrected by a sharp protest that all requests for transfer be decided by the Adjutant-General, "without prejudice, and not by the Commanding Officer, who will naturally be loath to lose efficient young officers." As a result of this and other measures, the quality again picked up, and by early February of 1918 a great reservoir of candidates had accumulated which it was realized would fill the schools for at least four months; after that it was

planned to take men from the ranks rather than from civil life. On February 9 all examinations were temporarily discontinued, and on February 23 final instructions were issued that "no further examinations will be made of civilian applicants for flying or non-flying commissions."

The task of sorting the desirable applicants was recognized from the start as one on which the efficiency of the Service largely rested. An extensive and quick-moving machinery was required, to operate in a field scarcely touched by psychologists. A network of examining boards had to be set up all over the country the moment the size of the personnel required became apparent. When the United States entered the war, there was only one aviation examining board, that at Washington, founded in October, 1916, and sufficient to serve the needs of the entire country until January, 1917. In that month a second was added, and a third and a fourth in April and May. In June, after the United States had been in the war eight weeks and the new programme had begun to loom up, four more boards were created, with a ninth in September. October, however, with the main programme finally launched, saw the number of boards more than doubled, with 12 new ones added during the month. The increase continued with five in November, seven in December, and three in January, till a total of 36 boards, located in practically every large city in the country, were in operation; during the same time 30 Divisional Boards had been set up at cantonment headquarters. These examining boards naturally required physicians of the very best type. Hundreds volunteered their services without charge, and a large

force of specialists was quickly built up to safeguard the Service to the greatest possible degree in its human material. In many cases hospitals and dispensaries also volunteered their facilities for this work.

Some idea of the problems thrust upon this new organization may be had from the fact that in the single week of December 19, 1917, 2,999 candidates volunteered for examination. The work could not be in any degree perfunctory; on the contrary, it had to be most painstaking and careful, both for the good of the man himself and for the good of the Service. A candidate temperamentally or physically unfit would be as well a danger to himself as a financial loss to the Government. Consequently, the examination was most rigid.

Each man's general character, presence, athletic ability, responsiveness, agility of mind, and past record were gone into as carefully as possible by a main examining board to see if he appeared of aviator type. Those who were sluggish, awkward or slow were thrown out. As the War Department put it:

> The candidate should be naturally athletic and have a reputation for reliability, punctuality and honesty. He should have a cool head in emergencies, good eye for distance, keen ear for familiar sounds, steady hand and sound body with plenty of reserve; he should be quickwitted, highly intelligent and tractable. Immature, high strung, overconfident, impatient candidates are not desired.

The medical examination was most thorough. After tests of heart, lungs, and blood pressure, came tests against obstructions in the nose and throat, which might cause vertigo or nausea to a man passing suddenly through wide ranges of temperature, and ex-

amination with the Jennings self-recording color-sense testor to assure good powers of observation. Most unusual, however, was the balance test, in which the candidate was spun rapidly around in a revolving chair and then asked to put his finger on a definite object. The spinning had set in motion the fluid in the labyrinth of the inner ear which controls the sense of equilibrium. If the candidate was normal, he would point slightly to one side of the object, and the disturbance noticeable in his eyes would last 26 seconds. If he fulfilled this test, he would stand a good chance of bringing an airplane out of a spiral or falling leaf.

Practically one man in every two was rejected in these examinations; to be exact, 18,004 out of the 38,770 candidates were thrown out. Possibly mistakes were made in some instances, but by and large it is safe to say that the United States was saved an incalculable amount of grief and expense by a system which stopped at the gates men temperamentally or physically unfit. The efficiency of the later training was correspondingly increased by the greater speed allowed in working with a very carefully selected personnel.

At the same time the examining boards had to sort out nearly 10,000 applicants for non-flying commissions, men for office work, production necessities, and administrative duties in squadrons. This was not an easy task, for many men came recommended by Congressmen and others who had to be handled with considerable care. In the period from July 14, 1917, to June 2, 1918, 6,470 such applicants were accepted and 3,225 rejected, mostly for physical reasons.

During the year, it may not be amiss to state, the mechanism of examination changed with the general change of policy of the Service. When the reservoir of cadets had accumulated in February, 1918, examination was suspended at 22 of the boards. In March five more boards ceased to examine, leaving eight still open for occasional work. Later still the ruling that practically all new cadets would be taken from Army camps rather than from civil life concentrated the work in the Divisional Boards at cantonments and brought practically to an end the work of the urban boards which had so finely met the emergency.

Successful applicants for flying service at once passed into the Signal Enlisted Reserve Corps for training. In the first weeks of the war their status was uncertain, but on July 13 Secretary Baker authorized payment to them of $100 a month and 75 cents daily for rations; on August 21 they were put on the same status as members of the Officers' Training Camps; and on October 29 they were designated as "flying cadets," entitled to wear a white piqué hat band. This status they held until they either passed the R. M. A. (reserve military aviator) test for a commission or were discharged as unfit.

The first assignment of the successful applicant was to one of the "ground schools," established, as previously described, at six large engineering colleges, and increased on July 5 to eight by the addition of Princeton University and the Georgetown University School of Technology. The colleges provided quarters, lecture rooms, teachers and certain equipment; the Government provided uniforms, military instructors,

and a tuition fee at first of $65 per pupil, and later, by an agreement of March, 1918, of $10 per week per pupil for the first four weeks and $5 per week thereafter. The purpose of these schools was twofold, first, to provide a basic knowledge of the sciences underlying aviation, and second, to uncover those who were shown in this more lengthy examination to be unfit to become aviators. That the latter provision was necessary is shown by the fact that one man was discharged for every four graduated from the ground schools.

During a crowded eight weeks' course the cadets were given preliminary instruction in the principles and theory of flight, radio, codes, aerial photography, meteorology, coöperation with the land forces, reconnaissance, etc., and taught to take an engine, plane and machine gun apart and put it together again. The curriculum included 190 hours in military subjects, 55 in engines, 52 in machine gunnery, 41 in airplanes, 41 in signalling and radio, 14 in map reading, 14 in artillery observation, 12 in aerial tactics, six in photography, four in instruments and compasses, and three in meteorology. Perhaps the most unique educational device was the "miniature range," which, viewed from a balcony above, exactly simulated a sector of the battle front. The cadets, seated aloft as in a plane, "spotted" various lights made to flash on and off on the range, and developed speed and accuracy in observation and in wirelessing their information to the instructor below.

These schools were of greatest value in acclimating the men in aviation and in supplying the all-important theoretical knowledge before actual flying began. In a sense they gave a complete view of the whole aerial

THE MINATURE RANGE FOR TESTING AND DEVELOPING SPEED AND ACCURACY OF OBSERVATION

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problem, as well as a familiarity with its details which were aimed to instill the confidence that always comes with knowledge. First conceived on April 30, 1917, and the first six actually opened on May 14, they had by May 23, 1918, admitted 16,620 cadets. Of these, 10,503 had graduated, 2,718, or one-quarter as many, had been discharged as unfit, and 3,394, about one-half the maximum capacity, were enrolled. Of the graduates, 8,373 had gone to American flying schools and 1,791 to flying schools overseas. The recollection that only 85 men were in training at the outbreak of the war will give some idea of the distance traveled the first year.

The second step in an aviator's training was taken at one of the new, large flying fields which had sprung up almost overnight about the country. The building of these fields was so large a part of the early aerial programme and had such big future possibilities in establishing a strategic aerial network over the country that it is well to digress here to give a summary description of this work. For this single phase of the programme $72,500,000 was appropriated, to be spent by Colonel C. G. Edgar, engineer and contractor, who had been put in charge of construction work on March 21. Within a year's time over $60,000,000 had been obligated, including $11,700,000 for a school, eight motor-assembling shops, aerodromes, hangars, repair shops, and concentration camps in France. During this first year 47 main projects were begun in the United States, of which 35 were completed. An idea of the size of the establishment needed to house the new air army may be had from the fact that there were completed in this first year 15 single-unit flying

fields and four double units, five supply depots, three concentration camps, three balloon schools, two repair depots, one experiment station, one radio laboratory, and one quarantine camp. At the end of the year there were also under way six single-unit fields, two supply and one repair depots, one mechanics' school, and two special stations.

The location of the flying fields was a most delicate matter, for in this most romantic of all phases of the war much pressure was exercised in favor of various localities, and great difficulty was experienced in making unbiased decisions in the limited time available. Sites were chosen by a board of officers and approved by the Chief Signal Officer, the Aircraft Production Board, and the Secretary of War. The saving elements in the situation were the rigid requirements as to landing space and the necessity of locating many camps in the Southwest to enable winter training. In the haste of selection a three-years lease with option to buy at a fixed price was adopted as the contractual basis the most equitable for the Government. Under this arrangement the Government could either abandon the field without prejudice or purchase it at any time within three years at its unimproved value. Rentals ran all the way from $1 a year, charged for Eberts Field at Lonoke, Arkansas, to $20,000 a year for Wilbur Wright Field at Dayton, Ohio. So also construction costs ran from $800,000 for a four-squadron field to double that amount, dependent principally upon the cost of leveling and drainage.

The initial need for a standard set of plans for plot layout, heating, lighting, water, sewerage, barracks, and the like had been met by calling in Albert Kahn,

architect, of Detroit, and his entire staff. In 10 days they laid out standard specifications on the lines especially of the Canadian fields, which were then sent to the Lumber Committee of the Council of National Defense for revision for the most economical use of lumber. The standard form of contract of the Council of National Defense was adopted, and the contractor, usually a local man, was named by the Emergency Construction Committee of that Council, aided in all cases by a Government superintendent of construction, with two or more assistants to oversee the whole and check prices.

Fields shortly began to open all over the country. Selfridge (Mount Clemens, Michigan), Chanute (Rantoul, Illinois), and Wilbur Wright (Dayton, Ohio) opened on July 14; Kelly (San Antonio, Texas) and Post (Fort Sill, Oklahoma) on August 11 and 24; Scott (Belleville, Illinois) on September 12; the three Taliaferro camps (Hicks, Texas) and Love (Dallas, Texas), on November 17 and 24; Call (Wichita Falls, Texas), Park (Willington, Tennessee), and Rich (Waco, Texas) on December 1; and Ellington (Houston, Texas) and Gerstner (Lake Charles, Louisiana) on December 15. Thus by mid-December, eight months after the United States entered the war, the number of fields where flying was actually taking place had increased from two to 18, and large-scale instruction was in full swing. By this time also there had begun to develop needs for other types of buildings to house the rapidly growing personnel and equipment. First came Langley Experimental Field (Hampton, Virginia); then assembly warehouses for interior use, at Dayton, and for overseas use, at Rich-

mond, Virginia, serving Newport News, and at Middletown, Pennsylvania, serving New York, Baltimore and Philadelphia; and finally, concentration camps at ports of embarkation, a series of central engine and repair depots, and a chain of Mexican-border and Atlantic-coast stations.

All this construction work in the United States was necessarily paralleled overseas. By the end of the first year 37 construction companies had been organized, trade-tested, equipped, drilled, and sent across to build in England and France the big fields, aerodromes and shop for which Allied labor was lacking. Large quantities of American material were sent also, so that when the American air forces began to move overseas, they found complete housing arrangements constructed largely by American workmen and of American material.

CHAPTER VII

THE TRAINING OF THE FLIERS

Courses of instruction for aviators — Primary training — Three stages in the flying course: dual work, solo work, cross-country work — The "Rules of the Air" — Cadets graduated as reserve military aviators — Advanced training — Three specialized classes of pilots — Recruitment of aerial observers — Training of observers and army-corps pilots — Training of bombers and bombing pilots — Training of pursuit pilots, the fighting force — Training of instructors — Aerial gunnery — Its development through synchronizing the machine gun with the airplane propeller — Royal Flying Corps system of training adopted — Aerial Gunnery Schools — Casualties in training — Their number and causes — Status of the training system at the end of the first year.

When the cadets came from the ground schools to these new flying fields, they found a course of instruction all worked out in the most minute detail — every hour filled with work, every source of danger warned against. From the very beginning the training of the fliers was prescribed with the utmost care, leaving just as little to chance as was humanly possible in a science depending so largely upon the individual. Step by step the cadet went on, always held back until he was doubly skilled in the present phase and doubly eager for the next.

From six weeks to two months was required to give a pilot his wings, dependent largely upon his own ability. Besides the actual instruction in flying, he was given at least 96 hours in aerial machine gunnery, 65 hours on planes and motors, 40 on radio, 24 on map reading, miniature range, and photographic in-

terpretation, 40 on military matters, 12 on drill, and 20 minutes daily in calisthenics. So far as possible all indoor work was concentrated on rainy days, when flying was impracticable.

The flying course proper, that is, the primary training, was divided into three distinct phases, successively undertaken with the increase in the flier's skill. First was the dual work, in which the cadet went up into the air with the instructor and was given opportunity to accustom himself to the feel of the plane. At the start he was largely a passenger, now and again, however, operating the controls as the instructor started, landed, or swept about the field at an altitude of about 500 feet. As rapidly as his skill warranted, he was given charge of the machine until he was able to get it up, down, and around with safety. All this time he was encouraged to advance, and at the same time he was protected against worry or nervousness by having impressed upon him the naturalness and simplicity of the whole performance.

After from four to nine hours of this work came the second stage, when the cadet first went into the air alone. At the start he repeated each phase of his dual work, and then he began to extend it until he was making figure eights at a 45-degree angle and gliding down with motor throttled from about 1,500 feet towards a previously designated mark. Next he was taught to make accurate turns with the banks approaching the vertical, to climb steeply to the verge of a stall, and to land in a very small circle. All of this work required another 24 hours in the air. All through the solo work the cadet was directed with great detail. Before each flight he received exact

instructions as to the evolutions, altitude and landing places, and after each flight he reported to the instructors for criticism. Never was more than two hours of flying a day allowed to any cadet, nor could flights be less than 20 or more than 40 minutes in length. Occasionally the instructor went up during this part of the training, to correct any bad form that might have developed. At the end of this solo work the cadet was master of the plane for simple flying over a prescribed field.

As the final step in this primary training came the cross-country work, beginning with a flight around a triangle 10 miles to a side, to give familiarity with prominent landmarks. Three flights, each 30 miles out and 30 miles back, then followed, at altitudes of at least 2,000 feet, the cadet receiving detailed instructions as to routes, landing places, and map. As much instruction in compass work and map reading was given as was possible with the number of planes on hand.

Perhaps this training can be visualized most vividly by going over a part of the maze of instructions, covering 14 closely printed pages, with which it was necessary to surround it. The "Rules of the Air" prescribed, for instance, that there was no right of way, but that every pilot must be wide awake at all times and see not only that he himself made no mistakes, but that the other men as well made none. An interval of 200 yards had to be allowed in passing another machine in the same direction, 150 yards in passing head on, and 50 yards in passing above or below.

Cadets were directed not to go up in a plane with-

out inspecting every detail of it and seeing that the tail-skid belt was safe-tied, all nuts cotter-keyed, braces taut, fuselage free from waste or rags, landing gear in good shape, and so on over the whole plane. If anything appeared wrong, strict orders were given "not to let your enthusiasm overcome your good judgment." A final inspection of throttle, switch, gasoline, oil and air pressure, and other instruments and controls was ordered before flight. The cadet was then directed to look in front, on both sides, behind, and above to make sure that no other plane was rising or landing. Thereupon he was ready to open the throttle, taxi straightaway down the field, and take off directly into the wind, never forcing the machine up until it was fully ready to go. Special caution was given against too steep a climb, too much rudder, and not enough bank.

All the time in the air the cadet was held responsible both for himself and for others, as collisions were usually fatal. Flights were always around the outer edge of the field so that the cadet might be able to glide home in case of trouble, and detailed instructions were given against the machine's sliding in or out, or into a nose dive or a tail spin. Spirals and glides were to be taken at about 2,000 feet altitude, with a bank of 45 degrees but without too rapid descent. At 1,000 feet the plane was to be straightened out and made to glide downward to earth into the wind. Cadets were told not to land while on a turn, which would throw the wing into the ground. If the landing place were found occupied at the last moment, full power ahead was ordered so as to circle back to make another try. After each landing the

CROSS-COUNTRY FORMATION FLYING, KELLY FIELD, MAY, 1918

cadet was told to ask himself if he had landed too fast, leveled off too high or too low, glided too steep or too fast, used too much rudder, or violated any rules of the air. On landing the plane was taxied to the dead line with elevator held forward to lessen the weight on the tail, except on soft ground or with a tail or side wind. The machine had to be pointed into the wind and the propeller left horizontal, so as to prevent its being broken off if the plane were blown over.

For cross-country work cadets had to see that their radiators and gasoline tanks were full, barometers at zero, emergency kit, map and blank telegrams ready, and instruments and controls functioning properly. In case the cadet got lost or had trouble, a field was to be picked out, preferably one already flown over, and a landing made after circling about several times to look for obstacles. No attempt was to be made to rise until a very careful examination of the ground had been made.

This, in brief, was the preliminary training of a flier. After the 60-mile cross-country flight and an altitude test of 10,000 feet, the cadet was considered to have passed his reserve military aviator requirements, which gave him his commission and the right to wear his wings. He was now skilled in all ordinary flying and was ready to go on to the advanced schools for acrobatics and specialized training for war work.

Up to May 23, 1918, a total of 4,094 reserve military aviators had been graduated from these schools, a number which may be compared with the total of 85 in training a year before. Of this number it is interesting to note also that 3,222 had been graduated

since January 1, and that a weekly output had been reached of 180 for the final week. At that date 3,997 cadets were in training at the 28 fields. Planes had been in the air for this primary work alone 274,255 hours, which at 80 miles an hour means that 21,940,000 miles had been covered. The selective process begun in the examining boards and continued through the ground schools was maintained also at the flying fields. Carefully chosen as the men had been, it was inevitable that many should prove unfit for flying when actually put to the test. Up to May 23 a total of 372 cadets were discharged, about one to every 11 graduated.

After graduation from the primary schools the R. M. A. pilots were sent on to advanced schools for final and specialized training which should fit them for actual war service in France. This training, which it was at first hoped could be had in France, was greatly delayed by the lack of equipment, as a very much finer materiel was needed for this work than for the primary training. Nevertheless, shift was made with what materiel was available, and the schools were able to do very appreciable work before the end of the first year.

So far as possible, pilots were allowed their choice as to specialized training, which fell into three distinct categories. First was the pursuit pilot of a single-seater plane, whose business it was to fight on every occasion, usually at a high altitude; next was the pilot of the heavy bombing plane, who was to go across country to the enemy's strategic points, more often than otherwise at night; and finally, the army-corps pilot, whose business it was to travel about with

the aerial observers in search of information and photographs — only occasionally of battle. Obviously these divisions of aerial warfare were entirely different and required very different types of men. A pilot hopelessly sluggish for pursuit work might make a very good bombing or observation pilot, and, on the other hand, a good observation pilot might not have the peculiar characteristics of a bomber. Within the limits of the service, however, the men were given as free choice as possible.

First let us take the aerial observers and the army-corps pilots. Very early it had been recognized that the former must be special men, not necessarily of the Air Service, who were familiar with artillery fire and who could interpret and direct it from the air. The observer therefore had to be an artillery specialist, driven by an army-corps pilot.

Early in September, 1917, an observers' school was in operation at Post Field, but only on a limited scale, largely because of the lack of planes and the difficulty of obtaining suitable personnel. The only definite source of observers at that time was volunteers from the ground schools, who were very scarce because of the greater attraction of pilot's work. An attempt during October to supply this scarcity from National Guard officers and enlisted men failed. On December 14, however, a clean-cut plan was announced, when the Chief of Staff directed 25 men to be sent weekly to Fort Sill from among the officers assigned as observers to the artillery in the various divisional camps. This plan was later found to disorganize the sending of the divisions overseas, and it was modified on January 24, 1918, so that all officers

so selected were definitely detailed to the Signal Corps in the proportion of 15 artillery, seven staff and cavalry, and three infantry. On February 15 Secretary Baker directed that the men chosen " be only the most desirable type of young officers; men who are capable, efficient and quick to learn. The success of the artillery operations and of the infantry attack in France may depend on the efficiency and the character of the artillery and infantry observers."

About January 1, 1918, a complete curriculum for the observers' course was drawn up in conference with four members of the Royal Flying Corps and two of the French Air Service. This provided for two weeks at the School of Aerial Fire at Fort Sill, six weeks at the observers' school, and two weeks more at an aerial-gunnery school. It was required, roughly, that an observer be able to send and receive eight words a minute by radio, make 12 good aerial photographs on 18 assigned locations, locate and direct artillery fire against enemy batteries, and conduct a prearranged shoot without error.

Meanwhile, of course, arrangements were made for pilots, to be known as "army-corps pilots," to operate the observation machines. They were chosen from the R. M. A. graduates, and were given a joint course, though for only four weeks, with the observers, the instruction being by permanent teams of two. Continuing their study of radio and gunnery, they added in their flights with the observers the instruction given the latter in aerial liaison with the infantry and artillery, going on with them later for two weeks at the aerial-gunnery school.

By May 23, 1918, observers' schools were in sub-

stantial operation at Post and Langley Fields. Handicapped though they had been by lack of planes and delay in securing material to build Langley Field, they nevertheless had graduated 335 observers and 255 pilots, and had a present attendance of 232 observers and 107 pilots. Of the observers one had been discharged for every three graduated, which well illustrates the early inferiority in personnel. During the course a total of 10,130 hours had been flown.

A second distinct course was that for bombers. What little work had been done along this line was stimulated into a definite programme by a cablegram from General Pershing about January 1, 1918, establishing that fliers should be trained in the ratio of five pursuit aviators, three observers, and two bombers. This cablegram gave the bombing programme a clean-cut status, and permitted its development as fast as equipment could be secured.

Ellington Field opened for bombing instruction on March 1 with 50 cadet bombers and 50 cadet pilots, followed by 40 more of each on March 18. The men were trained throughout in teams of two, always working together so as to have as perfect unison as possible between pilot and bomber and to build up a competitive scientific *esprit* between teams. The course was one month in length, with instruction in bombs, bomb sights, releases, day and night flying, formation flying, and study of enemy tactics. On graduation came two weeks of advanced aerial gunnery school, followed by practice in dropping live bombs selected as samples from those sent to the Ordnance Proving Grounds at Aberdeen, Maryland.

This course, requiring the most delicate materiel,

was seriously delayed by lack of such equipment as sighting mechanisms, dummy bombs, flares, field glasses, telescopes, recording barographs, Very pistols and cartridges; moreover, the JN-4H plane, a primary-training model, had to be used in default of regular bombing planes. Nevertheless, by May 23, 1918, 69 teams had graduated and 160 pilots and 115 bombers were in attendance. A total of 1,904 hours were flown at that single school in the week ending on that date, or 150,000 miles.

A third type of school was that for pursuit pilots, fliers operating small, fast, single-seater machines high above the battle lines, ready at any moment to drop down to attack a foe or aid a friend. Naturally the men selected for this work were those of stout physique and instant action, able both to stand the strain of high altitudes and to move with lightning-like rapidity in an emergency. The curriculum, worked out in conference with the British and French Missions, was very advanced, but the lack of actual battle-front single-seater planes and the substitution of the Thomas-Morse, American type, made it impossible to carry it through as far as desired. The first 16 of these planes had been received just after New Year's of 1918, with a total of 92 up to June 1.

All sorts of acrobatics and formation flying were prescribed, till the flier worked his way up through simulated battles with his instructor, with a two-seater plane and with another pupil, to final combat practice in formation. Special stress was laid on organization of the enemy front, enemy practice and machines, the theories of combat as individuals and in formation, and the effects of altitude, as, for in-

stance, on carburation. This training centered at Gerstner Field. Up to May 23, 1918, 101 pursuit pilots had been graduated, 18 transferred, and two killed. The attendance on that date was 140, and the hours flown in the final week were 1,335, or more for that single advanced school than for the whole Air Service in the fiscal year 1915.

To train all these men required a large number of instructors in many kinds of work. At first the service was greatly crippled by lack of such men, but as the first classes began to graduate, many of them largely by teaching themselves, fliers of instructor caliber became available. Later special instructors' schools were opened at Gerstner, Brooks (San Antonio, Texas) and Kelly II, where a certain proportion of graduates were given special training to fit them to take over later classes. Up to May 23, 1918, 252 men had graduated, and there had been a flying total of 23,245 hours.

After completing the specialized courses, all airmen were sent to the aerial-gunnery schools for training in what, for offensive work, was the most vital part of the programme. A pursuit pilot in a single-seater plane would have been entirely worthless, and other pilots, such as observers and bombers, would have been largely helpless against attack, if unskilled in aerial machine gunnery.

This science, like aerial photography and radio, was a development of the early days of the European War. The first British planes were wholly unarmed except for the revolvers of their pilots, who occasionally took pot shots at enemy aviators, and not until the Battle of the Marne was a British pilot wounded

from another airplane. It remained for the famous German Fokker plane to harness the machine gun to an airplane. Here was developed the synchronizing device which allowed a stream of bullets pouring forth at the rate of 500 a minute to travel between the arms of a propeller whirling around at a speed of 1,400 revolutions per minute. This development revolutionized aerial strategy and enabled offensive warfare on a large scale.

By the time the United States entered the war, aerial gunnery had been reduced to a science abroad. All the complicated interrelations of speed and deflections had been worked out, and calculations made as to how a machine traveling at a speed of over 120 miles an hour in one direction could hit another machine traveling equally fast in another, making due allowance for the curve of the bullet's course. The difficulty of aerial gunnery lay in applying these principles rapidly enough in all the different dimensions, directions and speeds in which the enemy might flash by.

During the early months of the war there was very little time and no equipment or knowledge to make much headway in aerial-gunnery training here. Some instruction was given at ground and flying schools, and on February 4, 1918, a central school to teach instructors the mechanism and construction rather than the operation of machine guns was established at Ellington Field, graduating 15 officers and 300 men on March 15. On January 4, however, the whole of the gunnery training was consolidated, and on the 7th Captain R. S. Potter, a graduate of the Royal Flying Corps school at Camp Borden, Canada, was

placed in charge, assisted by Major Wilson, R. F. C., formerly one of the chief instructors at the Central School in England, and 10 other officers training at Camp Borden. The policy had been adopted of taking over, in its entirety, the Royal Flying Corps system on the recommendation of the American Expeditionary Force that it was far superior to any other. No attempt was made to evolve a system here, nor were any changes to be allowed until the system was working and could be modified without loss of time. Complete notes, stencils, methods of instruction and appliances of the Royal Flying Corps were on hand, as well as four R. F. C. officers and six R. F. C. non-commissioned officers, with six more officers requested, and a quick system of liaison was established with England.

The aerial-gunnery training began at the ground schools with 52 hours of work on the mechanism, stripping, care, cleaning, causes of stoppage, loading and testing of the guns, but with no range mark. This was followed in the flying schools by 76 hours, introducing actual firing on the range, practicing against clay pigeons and silhouettes of enemy planes, and using the camera gun, which enabled the cadet to photograph instead of shoot at a nearby plane. This instruction continued in the advanced schools, varying in degree with the needs of the different types of pilots.

Just at the end of the first year, in mid-May of 1918, plans made some time before to give special machine-gun training to 1,000 men a month were carried out with the institution of special courses in aerial gunnery which all advanced-school graduates

had to attend before finally going overseas. Here for three weeks the pilots concentrated entirely on this work with many new elements added, especially target practice both from the air and from the ground at objects towed on the water or in the air behind other airplanes. This series of schools was seriously delayed by lack of equipment, for up to May not a gunnery plane had been delivered. While much time was required to make machine guns, even more was needed to make the synchronizing devices enabling them to fire through the propeller and the advanced training planes to carry them. Finally, however, on May 18 a school was opened at Selfridge Field for observers, and on the 25th schools at Ellington, for bombers, and Taliaferro, for pursuit pilots, each with a somewhat different programme.

In concluding this survey of the various courses through which a flier must go, it may not be amiss to discuss the question of casualties in training. Almost every day the press reported another fatal accident, sometimes several, till criticism began to be heard in several quarters and both Congress and the Aircraft Board ordered investigations.

The most vivid way to throw training casualties into proper perspective is to say that for every fatality a distance equal to seven times around the Equator was traveled. In other words, planes were in the air 2,319.57 hours per fatality, which at 80 miles an hour speed makes 185,000 miles. It is doubtful if so great a distance could have been traveled more safely in any other way. In terms of men trained, however, the figures were less favorable, as one death occurred for every 64.58 men to receive their R. M. A. wings.

THE MOUNTING OF THE MACHINE GUN

THE BOMBS AND THEIR RELEASING DEVICE

This, perhaps, gives a truer picture of the actual degree of danger in primary training; it well justified continuing to class aviation as a dangerous but by no means foolhardy service.

The causes of accidents were very interesting. Of the 103 fatalities from January 1 to June 3, 1918, 30 occurred as the result of tail spin, in which the engine stalled and the plane spun downward to the earth. The second highest number, 23, resulted from collisions, due to sudden fright or disobedience of orders, which are part of the human element very difficult to eradicate. Nose dives, in which the pilot shot down too steeply and did not have power to right himself, stood third on the list, with 19 fatalities; stalled engine, fourth, with six; sideslip, fifth, with four; fire, sixth, with three; and steep bank, collapse of plane, upside down, and hit by propeller, next with one each, leaving 14 undetermined.

This, in brief, shows the training of an airman. Whereas in May, 1917, there had been 85 students under instruction, there were a year later 3,997 in primary work, 193 in pursuit, 223 in bombing pilotage, 185 in bomb dropping, 266 in aerial-observation work, and 138 in army-corps pilots' work. Over 800 instructors had been trained and 25,800 men organized in squadrons at the fields. The primary training had been reduced to a routine and the three types of advanced training well established, though still handicapped by lack of equipment. By the end of the first year America had in operation a most extensive and detailed system of instruction, capable of giving her aviators all the training needed before their actual finishing work at the front.

CHAPTER VIII

THE TRAINING OF THE GREAT GROUND FORCE

Ground force required to keep a plane in the air — Requirements and training of non-flying officers — Supply Officers' School — Adjutants' School — Engineer Officers' School — Armament Officers' and Armorers' School — School for Compass officers — Training in aerial navigation — Development of aerial photography — Photographic Section created in the Signal Corps at the instance of the Committee on Public Information — School of Military Cinematography — First schools of aerial photography at Langley Field and Cornell University — Advanced courses in map compilation and interpretation for photographic intelligence officers — Kodak Park established by the Eastman Kodak Company — Courses of instruction — Aerial photography at the flying fields — Training of pilots and observers — Development of aerial radio-telegraphy — Radio instruction entrusted to the Signal Corps — Training of radio officers — Training of radio operators and mechanics — Radio Section created — Standardized courses of instruction — Importance of the ground force of mechanics — Difficulties and methods of recruitment — Necessity for specialized training — Schools at industrial establishments — Winter schools at Northern flying fields — Kelly Field mechanics school — Training at vocational schools.

The training of fliers, in all their various grades, by no means completed the new air army. If it required specialists to operate the planes, it equally required specialists to keep them up. In Europe it was commonly estimated that 47 trained men were needed on the ground for every man in the air. It is just this fact, the apparent disproportion of the results to the effort made, that will for a long time cause a lack of appreciation of the true difficulties and accomplishments of the Air Service.

First in point of emergence was the need for non-flying officers to do all the technical and administrative work necessary both at the flying schools and for squadrons in service. These included engineer officers to see that the planes and equipment were kept in first-class condition; supply officers to see that the proper amounts of ammunition, food, clothing, spare parts and other equipment were on hand; and adjutants to keep the records and make the necessary reports.

The first school, that for adjutants and supply officers, was opened at Kelly Field in mid-September, 1917, the first class graduating after seven weeks on November 7. The early classes were commissioned as first lieutenants, and considerable displeasure was caused when the shortage in that rank made it necessary to commission the later classes as second lieutenants. Very shortly, however, it was decided to abandon the Kelly Field school, which to January 12, 1918, had turned out 522 adjutants and supply officers.

The supply officers' school was transferred to the Georgia School of Technology, opening on January 12 for an eight weeks' course on the equipment and problems of motor transport, planes, engines, machine gunnery, radio and photography. On May 11, when the whole foreseeable demand for officers of this type had been filled, the school was finally discontinued, after having graduated 852 men and discharged 105.

The adjutants' school was opened at the Ohio State University, also on January 12, for an eight weeks' course. Up to May 25, 1918, 719 men had been graduated as second lieutenants and 88 discharged.

The attendance had been reduced to 90 at that time as the needs were being filled adequately.

The engineer officers' school, shortly after opening at Kelly Field, was transferred to Massachusetts Institute of Technology, where the technical facilities were excellent. Only men familiar with technical work were admitted, preferably technical-school graduates with engineering and administrative experience in engines, carburetors, magnetos, or shops working with wood, fabrics, metal, dope, wire, welding, vulcanizing or brazing. The first class, entering on January 5, 1918, with only 23 men, was forced to graduate considerably ahead of time, beginning February 15, to meet the great existing need, but on March 20 the course was definitely lengthened to three months with a considerably more detailed curriculum. The high standard set is shown by the fact that up to May 25 there had been discharged 214 men as against 448 graduated. At that time the enrollment was 325, and the object was to meet General Pershing's request of April 20 for 50 such officers a month.

Another course was that for armament officers and armorers to do the highly important work of testing and tuning all armament and of seeing that all machine guns and bombs were in good condition. The necessity for this work can only be appreciated when it is realized that scores of good aviators have been killed by reason of guns' jamming just at the critical moment. An armament officer with a score of men was needed for every squadron, to examine this equipment immediately before and after each flight. On April 22, therefore, a school was opened at Fairfield, Ohio, with 76 Signal Corps officers and 19 Ordnance

officers, and 500 Signal Corps and 80 Ordnance enlisted men. The course was to be six weeks in length and to include a complete study of machine guns, sights, interrupter gears, and the attachment, storage, upkeep and dangers of bombs.

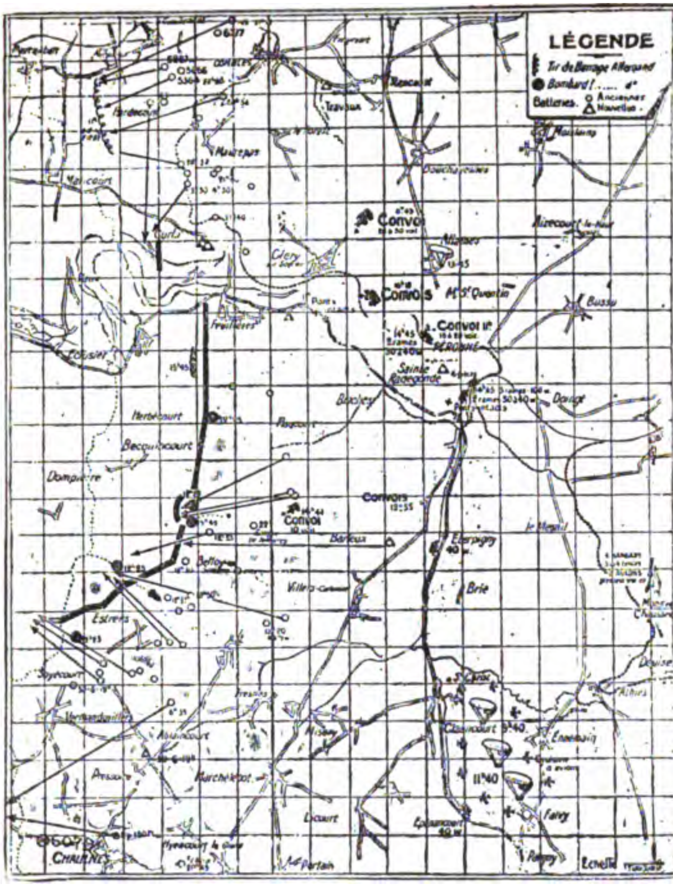
Another curious development was the school for compass officers, originated by a cablegram of February 4, requesting 50 such men as soon as possible. Experience had shown that the delicate mechanism of these instruments was thrown out of true with the magnetic pole both by the magneto and other parts of the plane and by jars on landing, and an elaborate system of correction had been developed, especially by the British. About April 10 Captain Fripp, R. A. F., arrived here to establish a compass course at Camp Dick, Dallas, Texas. Fifty-five graduates of the engineer officers' school were sent there with an equipment consisting of two planes, a number of bar magnets, compensating magnets. etc. The course lasted only 10 days, after which 50 of the graduates went overseas and two remained here for instructional purposes. From that time on the curriculum was consolidated with the regular engineer officers' course.

Somewhat similar was the course in aerial navigation carried on at Camp Dick at the same time, largely because of England's serious experience in losing many pilots and planes through loss of direction. Each of the 25 flying schools sent an officer who had been in charge of cross-country flying for ten days' instruction. These men later returned to the flying fields to disseminate what they had learned so that each pilot thereafter would have the best navigating instruction. It was expected at the time that one man

would be specially selected as navigating pilot for each squadron.

In addition to these courses for specialized officers were courses for the photographic, radio and enlisted personnel which formed the great bulk of the Air Service. The photographic and radio work was given both as a cross-section running through the airman's training and as special instruction for both officers and men on the ground. These features were so vital to the programme that they are worthy of special description.

One of the most striking developments of aviation in the Great War has been aerial photography. From the mere casual taking of single photographs from over the side of individual planes there had grown up a regular patrol of photographic squadrons on both sides of the line, keeping almost up to the minute a composite photographic reproduction of the whole enemy front and rear. Not a new trench could be dug or a new battery open fire but the piercing eye of the camera above engraved it with scientific infallibility on the General Staff maps. During the single month of September, 1917, the British alone reported taking 15,837 aerial photographs. Under the system as developed every sector of the front was divided into squares about half a mile to a side, each one numbered and entrusted to a squad of photographers, who became fully familiar with it. As fast as photographs were made, they were developed, reduced or enlarged to a standard scale, and fitted into their proper places on a large composite map. Cases were on record in which only 20 minutes elapsed from the time a photograph was taken over the enemy's lines till it had been



FRENCH AERIAL PHOTOGRAPHIC MAP OF AN AREA OF 96 SQUARE KILOMETRES IN THE PERONNE SECTOR, MADE BY PIECING TOGETHER AND "INTERPRETING" HUNDREDS OF SINGLE AIRPLANE PHOTOGRAPHS. THE HEAVY BLACK LINE INDICATES THE GERMAN TRENCHES. THE ARROWS SHOW THE DIRECTION OF FIRE FROM ACTIVE GERMAN BATTERIES; MANY INACTIVE BATTERIES, BOTH NEW AND OLD, ARE LOCATED. WAVY LINES INDICATE BARRAGE FIRE. SEVERAL CONVOYS ARE SHOWN AND THEIR DIRECTION OF TRAVEL INDICATED. IN THE LOWER RIGHT-HAND CORNER ARE INDICATED THREE BALLOONS PROTECTED BY NINE AIRPLANES.

brought in, developed, printed, and interpreted, and the batteries given the range and ordered to begin firing.

At the outbreak of war the United States had absolutely no facilities or knowledge for this work. All the highly developed methods abroad had been kept from this country as a neutral, and there was on hand in military circles here little but the knowledge of the existence of this science. Commercial companies who had endeavored to get some inkling of it had also failed. Moreover, aerial photography was necessarily a late step in America's development, which could not be taken until the immense preparatory work of building fields, training planes, and the like had been completed.

Nevertheless the framework on which all this development was to be erected was put together in the early days of the war, though for a somewhat different purpose. The Committee on Public Information, eager for official photographs of America's participation in the war, had during May, 1917, investigated the Allied methods and urged the Chief Signal Officer to establish a regular system for taking all official pictures. A request to this effect was made on June 2 to the War College, which on June 17 approved it, and two days later Secretary Baker entrusted the taking of all official photographs, both for publication and for historical work, to the Signal Corps. Accordingly, on August 2 a Photographic Section was organized for this purpose.

To complete this subject at this time, lists already prepared of motion- and still-picture operators were carefully gone through, the best men picked out and

commissioned, and a series of teams built up to take the immediately needed photographs of the early war work. This organization, however, proved insufficient, so a School of Military Cinematography was opened at Columbia University for a six weeks' course, graduating 114 men by May 23, 1918. From this school sections were formed of one second lieutenant, one sergeant and one private, who were ordered wherever photographers were desired. This force grew during the year to 40 officers and nearly 300 men, taking thousands of pictures and laying a large groundwork for the pictorial history of the war. With the separation of the Air Service from the Signal Corps proper, that photographic service stayed with the Land Division of the latter.

Meanwhile, the question of aerial photography was coming to the fore. In the fall of 1917 Major C. D. M. Campbell, R. F. C., and Lieutenant René Michel of the French Flying Service arrived in Washington to give this country the benefit of the Allied experience in this work. The mass of information which they offered proved invaluable, and in a broad way it became evident that both officers and men would have to be trained in taking, developing, printing, enlarging, and interpreting aerial photographs, and as personnel both for overseas squadrons and for the small instructional " huts " at the flying fields.

A technical school to furnish personnel to train observers in aerial photography, map interpretation and the use of apparatus was opened on September 19, 1917, at Langley Field with Sergeant-Major Haslett, R. F. C., supervising and with a composite system of instruction, using the British equipment and instruc-

tional methods and the French system of map interpretation. Very shortly the capacity of 150 men proved insufficient and a second school was planned, but never opened, at Fort Sill. A total of 228 men were graduated up to March 2, 1918, when the balance were transferred to the new Kodak Park and Langley Field closed for this work.

Another source of instruction was found at Cornell University, which had a splendid photographic equipment. On November 22, 1917, it was agreed that Cornell should allow the use of its photographic laboratories and enlarging cameras, and quarter, ration, and give military training to 30 men beginning December 1, while the Government was to furnish the necessary chemicals, plates, trays, instructors and curriculum, and $10 tuition fee for each student for the first four weeks and $5 weekly thereafter up to a maximum of $65. This school, opening on January 7, 1918, turned out its first seven graduates on February 9, and by May 4 had graduated 320 men and discharged 68. On that date the school was converted into an advanced school with a six weeks' course in map compilation and interpretation to train the most successful graduates of Kodak Park as photographic intelligence officers.

Still were needed, however, the hundreds of developers, printers, and laboratory experts for the great ground force which should make all this material available. Plans were made to open large schools at Ohio State and Princeton Universities, when an old offer made on July 14, 1917, by the Eastman Kodak Company of Rochester, New York, was recalled, and a letter was sent them on January 14 asking what

facilities they had available. The Company at once renewed its offer to provide for six months without charge a whole new building and the instructional force necessary for a school of 1,000 men and to arrange for rations at the standard Army rate of 90 cents a day. This plan was approved by the Secretary of War on January 21, and by March 10 several hundred specially qualified men had been sorted out, courses outlined, additional instructors secured, and the quarters arranged, so that the school opened on May 25 with 575 students.

The course lasted five weeks and followed three main lines. First came the laboratory and dark-room instruction, especially designed for fast news photographers familiar with developing, printing, enlarging, retouching and panchromatic photography, who were to be able to take a plate from an airman and develop it within ten minutes in large motor lorries or cellars close behind the front. Next was taught how to fit these finished prints into their proper places in the photographic reproduction of the German front, requiring men familiar with map compilation and interpretation, topographical science, and drafting. Third was instruction necessary to keep all this equipment in good condition, requiring camera and optical construction and repair men, lens experts, cabinet-makers, instrument makers, and other careful and expert workers.

The first class of 462 men was graduated on May 11. Most of them went straightway to overseas squadrons or to the photographic " huts " which were now assuming very appreciable form at all the flying fields. The most successful students, however, were sent on to

the photographic intelligence officers' school at Cornell, where they had advanced work in map compilation and interpretation and in actual conditions of field operations.

As fast as the graduates of these various schools had become available, aerial photographic "huts" had been opened at the flying fields for the double purpose of instructing the future airmen in this science and of giving continued and advanced work to the photographic personnel. At first these "huts" were somewhat alien to the flying course and had to make shift with any quarters and equipment available, but as the work developed, their buildings became part of the standard plans of the fields and their personnel was established as one officer and 24 men. With such facilities built up, flying cadets at the primary schools were given instruction in camera types and mechanisms, methods of obtaining continuous, overlapping, line photographs, the difference between vertical and oblique photographs, importance of flying level, stereoscopic photography, identification, and mosaics. For observers, who were to be very largely dependent upon this science, an advanced course was given, going deeply into questions of plotting, orientation, shadows, centers of resistance, trenches, listening posts, machine-gun emplacements, and the like.

The work in aerial photography was delayed throughout by faults of personnel and organization. Starting first as a separate division, it did not succeed in either winning or forcing a sympathetic hearing, and four chiefs in one year followed one another until the work was finally absorbed in the Air Division. For a long time information was not available on

which to lay down a definite programme, either from here or from overseas, and authority was lacking also for such important elements as the "huts." By the end of the first year, however, the big school at Rochester, the advanced school at Cornell, and the " huts " at the flying fields were in good operation and the groundwork was firmly laid.

An even more complex system or series of systems was the instruction in radio-telegraphic work, which not only followed the airman through the successive steps of his training, but also required a large separate ground force. Not only was it essential for every aviator, especially the observer, to be able to send and receive messages in the air, but special radio officers and operators were necessary to set up and maintain the equipment, to serve at receiving stations, and to do all the instruction work necessary.

Aerial radio had developed to an amazing degree during the war. Although all nations had experimented with it as far back as 1912, it was not in use in the first days of the war. Instead aerial signalling was done by dropping tinsel or smoke bombs or by making curious evolutions in the air. Very shortly, however, radio apparatus was installed on all military planes and the scope of the air service enormously increased.

On America's entry into the war, there were here, as elsewhere in the air programme, no facilities on hand, neither equipment, schools, instructors nor experience. The importance of training in radio work, however, was manifest at the moment the first ground schools were opened, and it was made a basic part of the instruction there. In October of 1917, it became

evident that this training must be greatly supplemented at the flying fields, and the curriculum of November 14 provided for a minimum of 40 hours. Due to lack both of instructors and of equipment, however, this early training was very elementary and inadequate.

To meet the lack of instructors and radio personnel, plans were made for a six weeks' course to graduate operators and repairmen at the rate of 100 a week, but no action was taken. Shortly it developed that the Signal Corps proper had such schools in operation, and a coöperative plan was agreed upon on November 22 whereby a school was opened at Ellington Field in January, 1918, with a limited equipment and civilian radio amateurs enlisted as instructors, which turned out 117 graduates by May 23. By December, 1917, the difficulties of radio personnel and training had begun to clarify and the needs became more sharply defined. A series of conferences developed the fact that 36 officers and 760 operators and mechanics would be needed for training and upkeep at flying fields here and 113 officers and 1,059 men for squadrons overseas. A standardized plan for a school with a capacity of 1,200 was drawn up, but it was not adopted because of a decision again to entrust all this work to the Signal Corps proper. Thereupon the Signal Corps undertook the training of air personnel at two officers' and three operators' and mechanics' schools.

For the officers' school, men of technical, electrical or mechanical education were sent for a 13 weeks' course at Maryland Agricultural College or Columbia University, the former graduating 47 officers by May

GROUND SCHOOL RADIO INSTRUCTION, RECEIVING AND SENDING IN CODE

GROUND SCHOOL INSTRUCTION IN MACHINE-GUN ASSEMBLY BLINDFOLDED, REQUIRING 70 SECONDS

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23, 1918, and the latter having 134 under instruction on that date. Another school, run by the Air Division at Fort Sill, graduated 30 officers. These radio officers were returned after graduation to the Air Service and sent to an observation school for a month's field course. Here they were required to organize and conduct a complete puff-target shoot, supervise the installation and adjustment of various types of radio apparatus on planes, set up and direct the ground receiving station, check the work of the observer in the plane and the receiving operator on the ground from a central receiving station, and work a puff-target shoot from the air. After this training they were ready for actual service in the field, at flying schools, or in instruction.

For radio operators and mechanics enlisted men were sought who had been telegraphers, electricians, and amateur radio operators in civil life. They were sent for an 11 weeks' course at Carnegie Institute of Technology, Pittsburgh, the University of Texas, or Texas Agricultural and Mechanical College, which opened, respectively, on March 1, April 1, and April 15, 1918. By May 23 Carnegie Institute had graduated 100 men and had 245 under instruction, 250 were under instruction at the University of Texas, and 300 at Texas Agricultural College. Many of these men were sent overseas at once; others went to flying schools, where they gave primary instruction and received advanced instruction as nearly simulating field conditions as possible.

With the turning out of these graduates came the opportunity to standardize radio instruction through the various stages in a flier's training in a way not

possible before. Whereas previously each ground school and each flying school had had charge of its own radio work, it was now decided to establish a Radio Section which should be wholly responsible for a progressive and coördinated scheme of training through the various stages.

Beginning with the ground schools, the curriculum laid down on April 1 provided for 43 hours of radio work concentrated entirely on efficient signaling from an airplane to the complete exclusion of other phases of telegraphy. The whole emphasis of the course was upon accuracy rather than speed, at first entirely by sound and later entirely by ear. Actual practice was afforded in spotting artillery bursts on the miniature range.

The flying-field curriculum was similarly revised on April 13, when an elaborate set of directions was sent out to each field. By these all radio instruction was to be put into the hands of the Radio Officer of the school, who was to be entirely responsible for equipment and training and was to be assisted in the instruction work by four radio officers and four radio mechanics, just then becoming available from the radio training schools. The curriculum called for a minimum of 40 hours and a maximum till qualified. Before a pilot could receive his R.M.A., he was required to be able to send and receive Morse code accurately at the rate of 10 words a minute for three minutes, to send at the rate of eight words a minute from a plane in flight, read service *panneaux* from a plane in flight at the rate of four code words a minute, and let out and rewind antennae five times from a plane in flight.

When the flier went on to the advanced schools, he found additional and advanced radio work awaiting him, both to keep him in practice and to perfect what he already knew. The pursuit pilots and bombers were given but 40 hours' work, but the observers, who would have to be in constant touch with the ground, were given 66 hours, 25 in receiving, 20 in sending, and 21 in lectures. By the time a flier was ready for the front, he was fully qualified in sending and receiving wireless messages in an airplane.

Thus by May 23, 1918, the whole radio programme had been concentrated and specialized. A continuous training system for fliers, with adequate instructors and equipment, had been built up, schools for specialized radio officers and men established, and radio officers and operators distributed on a set plan through the various flying fields and squadrons; indeed, the foundations had been generously and completely laid. The work throughout was handicapped, however, at the start by lack of equipment and of information from overseas, and later by confusion in policy as between the Air Division and the Land Division of the Signal Corps, which was not to be finally cleared up until the divorce of the two services by the reorganization of May, 1918.

Undoubtedly one of the most serious problems, and one not early appreciated, was that of providing the great ground army of mechanics needed to keep the planes and all their delicate equipment always in good condition. When it is remembered that a battle plane is the closest possible compromise between speed and safety, that it has been stripped down to the last ounce of weight, and that a slight error in any one place

may mean death, a little idea of the vital importance of this force may be had. Indeed, without a good ground force the airmen would be useless. If the men in the dromes and repair shops have not done their work well, no amount of courage and skill will avail. As soon as anything happens to the plane, the aviator is as helpless as a bird with a crippled wing. He has only one course before him, to alight at the earliest possible moment. Many a famous flier has been killed in a defective plane.

The problems of securing this necessary ground force were very great. The drain upon skilled mechanics had been tremendous; thousands had gone in the draft, and other thousands had been attracted by unprecedented wages to war industries. During the first few months of the war no special arrangements were made for increasing personnel, but by the middle of October, 1917, the need of greatly increasing the number of men became apparent. A special recruiting section was then formed, which received greatly added impetus when it was announced that no more voluntary enlistments would be permitted after December 15. An extensive publicity campaign was also inaugurated, which utilized 225,000 posters, 125,000 booklets, and newspaper and magazine articles, distributed through draft boards, recruiting offices, post offices, clubs, garages, and the like.

Other methods of recruiting were instituted at about the same time. General Pershing cabled urging immediate steps for "conserving personnel especially suitable Air Service," and on November 1 a memorandum was sent the Chief of Staff that "the difficulties of obtaining an adequate and suitable personnel

confirm this judgment." It was "of pressing importance," therefore, that 5,000 mechanics be transferred at once from the National Army to the Air Service. This was approved on November 22, the same day that another memorandum was sent to the Chief of Staff requesting the induction of 9,000 men monthly for the five months from December to May to complete the 45,000 men needed of the 87,000 authorized by December 1, 1917.

During all this time the number of men needed was increasing. On October 16 came authority to enlist 12,000 motor mechanics to release for airplane work a similar number of Frenchmen engaged in the transport service. On December 17 came orders to secure 9,900 men for the spruce forests; on December 21, orders for 12 companies of bricklayers to build aviation schools in England; and on March 20, 1918, orders for 27 more companies of bricklayers and construction men, totaling 9,750. This brought the authorized strength of the Air Service to 11,011 officers and 120,737 men, nearly as much as the whole Regular Army before the war. As a result of all these demands and methods of filling them, the enlisted strength of the Air Service went up by leaps and bounds. Whereas on August 1 it stood at 10,107, on September 1 at 19,598, and on November 1 at 22,067, by December 1 it had jumped to 36,234, by January 1, 1918, to 87,425, by March 1 to 109,372, by April 1 to 128,569, and by May 31 to 137,972, of whom 38,889 were in France. Indeed, the enlisted strength had so far exceeded what was authorized for the Air Service that on March 13 all inductions and enlistments were ordered to cease.

Mere numbers, however, were not sufficient. As a memorandum of December 3, 1917, put it:

> Investigation shows that it is practically impossible to obtain welders, there is no such thing as airplane mechanicians to be had; the few armorers in the country cannot be spared from their work of manufacturing; to take propeller makers from the airplane factories would interfere with their airplane production. It is, therefore, suggested that some definite means be taken to train men for the special work required, preferably men from industries closely allied, and men whose training and experience has been along somewhat similar lines.

The problem was only half solved, therefore, with the enlistment. First was required the inculcation of a care and a thoroughness wholly foreign to American quantity-production methods. The men had to be educated to a new standard in the delicate work called for in order to guard against the little-evident wear and tear on a mechanism already lightened to the breaking point. Obviously this new perception could come to the workmen only with constant effort and experience.

Early in October, 1917, the first step towards a comprehensive system of mechanical instruction was taken by sending letters to a score of specialized factories, asking if they would admit squads of soldiers for training purposes. It is a tribute to American industry that this request was most willingly complied with, although many of the factories were using special processes and all would be considerably inconvenienced. The first squad of 25 men was sent to an oxy-acetylene company on November 11 for a three weeks' course in welding, which had been alarmingly

unrepresented among the recruits. Within two weeks 300 men had been scattered in small squads among 14 different companies and the Royal Flying Corps camp at Toronto for courses of from three to eight weeks in armament, ignition, airplane motors, propellers, machine guns, instruments, sailmaking, vulcanizing, cabinet work, copper work, motorcycles and motor trucks.

These schools proved very successful, and on January 15, 1918, three more were added to give instruction in airplane construction, airplane motors, and tire work. Later on, as the general scheme of mechanical training began to develop on a broad scale through the establishment of several large schools, it was decided to cease instruction of small scattered groups at the factories and to consolidate the whole training under more thoroughly military conditions. In March, therefore, the Chief Signal Officer ruled that these smaller schools, which had served so well in the emergency and turned out over 2,000 specialists, should be abandoned as rapidly as other facilities became available.

But further facilities for instruction were necessary from the start. Some became available when the coming of winter closed the five Northern flying fields of Scott, Chanute, Selfridge, Hazelhurst and Wilbur Wright. With the pilots gone and much equipment remaining, it was decided on November 1 to employ these schools during the winter for mechanical instruction. First, however, it was necessary to secure instructors. To this end a circular was sent to leading airplane and engine factories and garages asking men experienced in motors, carburation, ignition, or planes,

especially foremen used to handling men, to apply for this work. A special examining board picked out 17 civilians as first and second lieutenants, 48 in ranks from corporal to master signal electrician, and five as aviator mechanicians. These men were given an intensive three weeks' training at Selfridge Field beginning December 8 and then distributed through the various fields as an instructional force. The schools themselves opened on January 1, 1918, with about 315 students and a curriculum covering woods, propellers, wing repair, fabrics, wire work, soldering, tires, alignment, fuselage, motors, and later motor transport. Though delayed somewhat by quarantine for measles and by slow shipments, these schools by April 1, when they were closed because of the reopening of flying instruction, had graduated 30 welders, 574 motor mechanics, 1,120 airplane mechanics, and 939 motor-transport men.

Meanwhile, Kelly Field, the great Texas concentration camp, was also developing as a mechanics' instruction center. A school had been opened there in mid-November to give as much training as possible under the disadvantageous conditions then prevailing, but on December 29 it was reported as unsatisfactory because the teachers were inexperienced, the equipment insufficient, the courses not specialized, students transitory, and the officers overworked. In March the whole school was reorganized, the instructors given an additional intensive course, and the school reopened on the 18th with a capacity of 1,000 men. To June 30 it graduated 195 chauffeurs, 419 airplane mechanics, and 300 motor mechanics.

Not even these schools all in operation together were

ENGINE SCHOOL FOR AIRPLANE MECHANICS, HAZELHURST FIELD, MINEOLA, LONG ISLAND

sufficient for the increasing needs, and it was decided that the whole mechanical instruction must be very much further amplified. Accordingly, three large vocational schools were turned to early in December, 1917, to undertake the work on a broad, centralized basis. The first trial detachment was sent on December 10 to Dunwoody Industrial Institute at St. Paul, Minnesota, split into five groups of five men each to try out various courses. The facilities were found to be adequate, and the Liberty Ignition School, which it had been proposed to open at the Dayton Engineering Laboratory, was transferred here and opened on January 1 with 50 students and five of the Company's best technical men. Meanwhile negotiations had been completed on a broader scale with Pratt Institute in Brooklyn and the David Ranken School of Mechanical Arts at St. Louis, and on January 5 authority was asked to train a total of 2,160 men at a cost of $41,000, or $18 each, at these three schools in the interim before Kelly Field reopened in June. This plan was approved on January 15.

Dunwoody Institute originally offered to train 400 men a month free of charge till April 1 and then to charge $3.50 per man per week. The plan developed rapidly, however, until authority was secured to train 2,000 men at 45 cents each daily and to spend $254,500 for quarters. The school opened on March 1, giving instruction in airplanes, motors, motor transport, ignition, sailmaking, vulcanizing, cabinet work, carpentry, motorcycles, metal work, and instruments. Shortly it was taken over by the Government and it was later retained as one of the two Government mechanics' schools. Pratt Institute, though delayed in opening

by a search for quarters and the necessity of remodeling the building, opened on March 18 with 200 men for a four weeks' course for carpenters, cabinetmakers, and motor mechanics under an agreement to take not over 1,000 men before June 1 at $4 each. David Ranken School, also delayed by lack of equipment and instructors, opened on March 1 with 141 men for a four weeks' course for carpenters, blacksmiths, electricians, metal workers, propeller men, and motor mechanics under an agreement to take 360 men before June 1 at a cost of $10,000. A fourth school of the same type was opened at the Carnegie Institute of Technology on January 25 with 60 men, without charge to the Government, for a four weeks' course for coppersmiths, blacksmiths, and motor and airplane mechanics.

Thus the training of mechanics, so vital to the success of the Air Service, developed through various stages under great difficulties. Nearly a score of small schools opened at special factories to meet the first needs turned out about 2,000 men and were then abandoned. The Northern flying fields, opened for this work in the winter months, turned out another 2,500 men before the return of flying in the spring. Four large vocational schools, next turned to, graduated another 5,500 men before the end of the first year of war, when the Government was considering abandoning them in favor of two complete Government schools at Kelly Field and St. Paul, Minnesota, with three months' courses. All the way through this work was greatly handicapped by lack of equipment, tools, planes, engines, space, quarters and instructors, and delay in securing authority to go ahead. Never-

theless, by May 1, 1918, over 10,000 men had been sent within 6½ months through 17 different courses at 34 different schools, and the immediate pressing needs both for overseas and for the flying fields had been met.

CHAPTER IX

REACHING BACK FOR RAW MATERIALS

Complexity of the industrial problems of materiel — Mobilization of raw materials and creation of new industries by the Government — Spruce the foundation of the airplane — Spruce forests of Oregon and Washington — The logging industry at the outbreak of war — Its reorganization under Government control — The I. W. W. and the labor situation — Thirteen thousand troops sent into the spruce forests — Spruce Production Division organized under Colonel B. P. Disque — Loyal Legion of Loggers and Lumbermen created — Wage adjustments — Spruce requirements and production methods — Substitutes for spruce adopted — Kiln drying of lumber — Reorganization of lumber transportation — Linen for airplane wings — Failure of the Irish supply — Development of a cotton substitute — Shortage of airplane dope — Development of supply of acetate of lime and other constituents — Engine lubricants — Castor oil an essential for rotary engines — A hundred thousand acres planted to castor beans — Development of a standard mineral lubricant — The Liberty Aero Oil and the tragedy of its consummation — The problem of special equipment, instruments and accessories.

Complex as were the training and personnel problems of the Air Service, they did not require the extent of preparation and the time that the material and industrial elements required. Given a man physically qualified, his training can begin as soon as fields and equipment are ready, but to build a plane or an engine one must go far back into the sources of raw materials and the basic, preliminary industries. Consequently, in a country replete with man power but very deficient in all the industries that go to make up an Air Service, industrial development was certain to make a far slower start than the recruitment and training of personnel.

Of all the vital industrial preparation of the first year, probably the most fundamental and far-reaching factor was the mobilization under direct Government control of essential raw materials and accessories, the scarcity of which bade fair to stop the whole aerial programme before it even got under way. The Government, beginning slowly and cautiously, was driven on step by step by undeniable and unprecedented demands until it finally found itself directing and financing a whole series of industries of the widest diversity. In any estimate of this first year of aerial preparation, it is essential to understand that no one at the outset realized that it would be necessary to send thousands of soldiers into the forests to get out spruce, provide millions of dollars for dope factories, plant 100,000 acres to castor beans, or develop wholly new lines in linen, barometers, and a dozen other materials and instruments. Undoubtedly had the scope of all this preliminary preparation been foreseen, a very much larger organization would have been created.

Spruce is a very good case in point. Toughest of the soft woods, with unsurpassed shock-absorbing qualities, and not apt to splinter under bullet fire, it was early recognized as the very foundation of the airplane. No other wood so well combined the essential qualities of lightness, strength and resiliency, or came in such long, clear lengths free from knots.

Spruce of the size needed grew only on the moisture-laden Cascade Range slopes of Oregon and Washington, where in immense primeval forests giant trees a dozen feet in diameter and 300 feet in height flourished in apparent safety. Only about one-third of the 11 billion feet of Sitka spruce, however, was dense enough

or near enough to possible logging operations to be available, and the difficulty was greatly increased by the fact that only a very small proportion of the tree as cut could be used in airplane work. As a matter of fact, about 14 per cent. of the original tree was sent to the mills, and of this only one-third, or 4½ per cent. of the lumber cut, was of the desired quality. A very large cut had to be made, therefore, to get out a very small amount of airplane spruce.

At the time the United States entered the war, a small and unorganized industry was working in at the edges of this western spruce tract under rather chaotic conditions. The Allied Governments, England, France and Italy, competing ruthlessly against each other through lumber brokers, had sent prices up to the extravagant figure of $250 per thousand feet. The forests, moreover, were seething with labor unrest, the method of cutting was very primitive and wasteful, standard specifications were entirely lacking, and shipments east by commercial freight wasted months of time.

The Government at once realized that with the United States also in the market the situation would become impossible. As a first step a representative of the Lumber Committee of the Council of National Defense was sent to the Pacific Coast in May, followed in July by an educational mission of French, British and Italian aviators, personifying the close connection between forest and battle front. Early in the latter month the 40 leading operators agreed to let no more contracts until the Government's needs were known, and later the Aircraft Production Board announced that all airplane spruce would be purchased by the

A GIANT OF THE OREGON SPRUCE FORESTS

Government. In August the Emergency Spruce Council and the Pacific Aircraft Spruce Production Board were formed on the Coast, knitting together all the previously scattered interests; and on October 5 a committee was appointed by the Government to place all contracts over a period of 18 months, to establish prices, and to recommend advances.

Finally, also in October, came one of the most drastic steps yet taken by the Government in the war. The enormous amount of spruce needed under the new American programme and the impossibility of supplying it under present conditions had become increasingly evident. In the emergency Colonel Brice P. Disque, who had recently achieved considerable renown as acting warden of the Michigan State Prison, and who had been sent out to the Coast to investigate the spruce situation, recommended the sending of a force of Government troops into the forests to assure an adequate supply of spruce against all eventualities.

The labor situation at the time was desperate. Not only had a large number of woodsmen been taken off by the draft, by voluntary enlistment, and by the opportunity of higher wages in the shipping and munitions industries, but the remainder were infected with the pacifist and anarchistic views of the I. W. W. Some idea of the situation may be had from Colonel Disque's report of November 2 that the I. W. W. had reduced the spruce output by 30 per cent. by "drawing water from boiler and then firing to white heat," "placing emery powder in bearing and cylinders," and "cutting fine spruce logs into short lengths." Similar conditions were reported by the President's

Mediation Commission on November 9, with the statement:

> This basic world industry suffered a breakdown of several months in the summer of 1917, and is still in a state of seething unrest, woefully short of its productivity, for while the strike of 1917 was broken and the men went back beaten for the moment, the conflict was only postponed and not composed. Some of the men practiced "conscious withdrawal of efficiency," the so-called "strike on the job," and there is every expectation that unless present conditions are changed, a complete strike will take place in the Spring.

The I. W. W. was described as "a band of groping fellowship," filling the vacuum caused by conditions at the camps, a migratory drifting labor, and the hostility of the employers to labor unions. The only solution was said to be the eight-hour day, accepted in all other coast industries.

The plan to send troops into the woods, which it was feared by some might be interpreted as an attempt to coerce labor, and by others as productive rather of casualties than of spruce, was approved by the Aircraft Board on October 11 and by the Chief of Staff on October 17. Colonel Disque was put in charge of the Spruce Production Division on November 6, with a force of 66 squadrons, or nearly 10,000 men.

The first step taken was to attempt to win the confidence of the woodsmen by instituting the Loyal Legion of Loggers and Lumbermen, an entirely voluntary organization under Government patronage, aiming to improve conditions, establish an *esprit de corps*, and instill the feeling of patriotic service. Washington and Oregon were divided into seven districts, an officer was sent into each to arrange for the organiza-

tion of locals, and on November 30 the first local opened at Wheeler, Oregon, with 110 members in a camp of 110 men. A sanitation officer was later sent to each camp to survey living conditions, and two officers with motion pictures were sent about to relieve the boredom of lumber-camp life. By May, 1918, 75,000 men had been enrolled, minute conditions of sanitation prescribed, and sabotage brought practically to an end.

Wage conditions, however, remained to be settled. On February 27 a conference of all the employers was called to consider the men's chief demand, the basic eight-hour day, over which the industry had been split for over a year. The decision was finally put into the hands of the Government, and on March 1 the whole industry went on a basic eight-hour day for a six-day week, with time and a half for overtime. "The life of your nation and the safety of the world," said the announcement, "is largely dependent on spruce production," and "reduction of production by wilful neglect on the part of either employer or employee is no less treason than would be a strike or disobedience of orders among soldiers or sailors."

Troops were now arriving in large numbers. By February 1, 4,600 had reached Vancouver Barracks, Washington, 1,100 of whom already in the woods had greatly stabilized conditions. By June 13,000 men were on hand, with 8,000 in the forests. These men were assigned in multiples of 25 to lumber companies producing Government airplane spruce, the Government paying their wages as soldiers and the companies refunding that sum to the Government and paying the men the difference between the Army rate

and the prevailing civilian pay for similar work. The men, who were under military discipline, with their living conditions prescribed by the Government in detail, kept on good terms with the civilians working alongside them.

Meanwhile the demands for spruce kept running continually and alarmingly ahead of the supply. Whereas 26 million feet had been turned out in 1916, the estimate kept mounting from 36 million feet annually in May, 1917, to 11½ million feet monthly in September, 14 million feet monthly in December, and a final figure of 23 million feet a month in June, 1918. The early production estimates in August, 1917, gave a maximum of 75 million feet annually. It was obvious that many other measures for increasing production must be taken.

First in point of time was the drafting of standard specifications for cutting, through which it was hoped that waste could be reduced both at the mills and at the factories. Before the war there had been no definite, uniform standards, and as a result a great amount of good wood was cut in unusable lengths, this causing also a large loss in transportation efficiency. The Government laid down standard specifications applicable to all mills, scientifically worked out to cut the logs in the most economical way.

Closely allied was the Government "cut-up" mill, the largest sawmill in the world, designed especially to economize lumber through a new arrangement of saws which could work far more efficiently than the conventional saws in use at ordinary commercial mills. Twelve separate log carriages conveyed the

THE GOVERNMENT CUT-UP PLANT AT VANCOUVER BARRACKS, WASHINGTON, ON THE TWENTIETH DAY OF CONSTRUCTION

logs to 12 head saws, back of each of which was a full equipment of edgers and cut-up saws, each driven by a separate electric motor. By this arrangement the airplane spruce cut from a given log was increased from five to 10 per cent. The mill was begun on December 24, 1917, and completed in 45 days. Construction was carried out largely by volunteers from the soldiers at the barracks; rails for spur tracks were secured from sidings torn up some distance away; and unavailable machinery was turned out on special designs by local foundries. The mill covered five acres, and its full-time capacity was lumber for 1,000 planes a day, with a labor force of 1,940 soldiers working in three eight-hour shifts.

An expedient adopted in November, 1917, against all traditional practice but necessary to keep up the flow of wood while roads and tracks were being built further into the forest, was the "riving," or splitting longitudinally by driving in wedges, of logs cut to the proper length. Thus trees otherwise wholly inaccessible were reached and the rived sections taken out where the whole logs could not have been. This system, in splitting the logs lengthwise, at once disclosed any bad grain, but it involved a wastage of 70 per cent. of the rest of the tree, which had to be left where cut.

Substitutes for spruce were also adopted. On December 26 fir, which is heavier and stronger but more subject to splintering than spruce, was authorized for all training planes as soon as available, spliced spruce being used in the meantime. On February 8, 1918, it was approved for the De Haviland battle planes,

except for the interplane struts, wing beams, landing-gear struts, longerons and rudder post, and on March 23 some of these exceptions were abolished. Again, on April 24 several other kinds of woods were authorized, such as Port Orford cedar, yellow poplar, western white pine, western hemlock, western yellow pine, ambilis fir, grand fir, noble fir, and eastern white pine.

Kiln drying of lumber was largely developed. Whereas before the war weather drying had required two years and kiln drying had caused, in the case of the Curtiss Company, for instance, 40 to 60 per cent. rejection of lumber, in February a new system was ordered installed at Vancouver Barracks, at a cost of $350,000, which completely obviated these difficulties. Beam struts were finished in 12 days, and smaller struts in seven. The decrease in weight by one-third of wood kiln-dried, the prevention of mould and decay, and the saving of space caused this process to be suggested for all shipments, including those to the Allies overseas.

Moreover, transportation problems were greatly simplified. Previously it had taken 60 to 190 days to cross the continent, and in many cases lumber had piled up to such an extent that the mills had to be closed. The policy of individual car shipments was discontinued, and aircraft shipments were consolidated with other Government lumber for direct shipment through to eastern points in special trains on Government priority. The time of transit was thus reduced to an average of 15 days. At the same time control and distribution of the limited car supply was also assumed, in order to provide a just distribu-

tion of cars and relieve mills of congestion with commercial lumber.

Throughout the Government acted as general purchasing agent for the mills and operators of the section. So far as possible the equipment required by different companies was standardized to expedite production and ordered wholesale on Government priority. What this work was may be seen in purchases up to June, 1918, of six million feet of wire rope, 200 miles of rails, 175 logging engines, 10 tons of wedge steel, and innumerable jacks, steel cranes, and electric motors.

As a result of all the efforts put into spruce production the following shipments, which give a graphic idea of the progress of increase, were made:

	Cars of Spruce and Fir Shipped	Spruce Shipped by Mills, feet	Fir Shipped by Mills, feet
1917:			
August	9	202,264	....
September	121	2,638,329	....
October	154	3,400,611	43,006
November	245	3,212,325	1,587,744
December	184	3,519,823	1,344,053
1918:			
January	242	3,507,290	2,533,565
February	352	10,846,420	7,178,136
March	471	9,317,929	3,423,960
April	...	11,216,859	5,404,000

This, in brief, is the story of spruce, beginning in labor troubles, lack of organization, and incompetent methods, and running through to a most promising, though not yet completely satisfactory, production. In the first year of war labor trouble had been wiped

out by the eight-hour day and good living conditions; the scattered operators had been knit together under Government direction; Government standards, a cut-up mill, and purchasing facilities had been established; 13,000 soldiers had been set to work; and a production of 11 million feet of spruce per month, or nearly half that of all of 1916, together with over five million feet of fir, had been reached in the single month of April, 1918.

Next most serious of the shortages of raw materials was that in linen, the only fabric discovered abroad for covering the wings and other parts of airplanes that combined the essential qualities of lightness, strength, resistance to tear by bullets, and affinity for dope. Practically the only source of supply was Ireland, which had an extensive linen industry based on flax grown there, in Belgium and in Russia.

Early in the war, on May 5, 1917, the United States began negotiations with Great Britain to secure of this Irish linen the 1,500,000 square yards required for the limited programme of 3,000 planes then contemplated. Great Britain at that time had been forced by the growing scarcity of linen to take over the whole supply and allocate it among the Allies in accordance with their needs. Under this arrangement the United States was allotted its proportion, the initial orders being placed on June 5. At first the Government tried to interfere as little as possible with the regular linen importers, but shortly it developed that indiscriminate buying abroad was not desirable. Accordingly, Peter Fletcher, representative in England of a leading American firm, was named as representative of the Government and the trade.

Great Britain soon afterwards requested that the American Government itself, instead of individual firms, place all orders through Mr. Fletcher and then allocate the shipments as it saw best among airplane manufacturers.

By July, however, the linen situation had taken a more serious turn. On the one hand, American needs had grown with the new programme to the large figure of 1,800,000 yards for the six months ending December 31, 1917, and 10,000,000 yards for the year 1918. On the other hand, the cutting off of the Russian flax supply by the revolution and a series of strikes in Ireland greatly reduced the supply of linen available, so that shipments became more and more irregular. It became apparent that some substitute must be found, especially as cables in December requested the use of substitutes in training planes.

Cotton was unquestionably the logical choice, but strangely enough neither England nor France, despite their high development of the textile art, had made any advance in this direction. Both nations had developed "fine goods" fabrics, which were, of course, wholly unsuitable, and had taken the first steps in mechanical fabrics with typewriter ribbons, corset cloth, and automobile tire cloth. There, however, they had stopped. A purchase of 40,007 yards of best British cotton fabric, at the urgency of that Government, proved wholly unfit for airplane covering.

Thus the Air Service was confronted with the necessity of developing a suitable airplane cotton from first principles. As there was no one in the Signal Corps who had any special knowledge of this work, Albert Tilt, a textile expert, was commissioned cap-

tain about August 1, 1917, to have it in charge. Considerable progress, it was discovered, had already been made in experiments conducted for over a year by the Bureau of Standards and the National Advisory Committee for Aeronautics. Aided by the knowledge already gained and in further coöperation with these two bodies, the Signal Corps began a series of tests of various fabrics already developed, both at Langley Field and at several cotton mills. The problem was to develop a cotton fabric lighter, less liable to rip or become loose under tension, and with a greater affinity for dope and varnish than any of those then available. One fabric after another was tested, not for appearance or other superficial features, but for actual tensile strength, durability under exposure, non-stretching qualities, and the effects of surface friction. Gradually the desired characteristics were developed one after another until a definite foundation of experience had been built up.

The knowledge gained from all these experiments was put into the form of specifications, and the Ponemah and the Pierce Mills were induced in September to break into their regular work to turn out 10,000 yards each, with the Nashewena Mills added later. On September 15 $12,000 was allotted for experimental work in conjunction with the Bureau of Standards and the Department of Agriculture, and a corps of four textile experts were placed at the mills to conduct spinning tests with different grades of yarn. Samples as fast as developed were placed upon machines at Langley Field and Pensacola and tested before representatives of the Allies and the airplane

manufacturers, who agreed that highly satisfactory results were obtained.

At last, with a suitable fabric developed, the best mills were asked to submit samples according to specifications, and on October 11 the first quantity orders were placed for 500,000 yards among five mills at a price from 55 to 62 cents per square yard, considerably less than the cost of imported linen. On November 16 new and improved specifications were issued and orders placed for 1,000,000 yards, and three more orders followed on December 27 for 500,000 yards each. Up to May 23, 1918, the great figure of 15,933,600 yards had been ordered from 11 companies at a cost of about $9,000,000. A total of 1,875,877 yards had been delivered to that date, with 460,563 yards produced in the final week, an annual production rate of 23,000,000 yards. Importations of British linen, which totaled 3,865,351 yards by June 1, were no longer necessary, so that it may be said that at the end of the first year the country had not only met all its needs in this basic element of the air programme, but had also established a new and very economical substitute for linen, equal in all respects and superior in many, costing about half as much, and certain of having a very large peace-time value.

Another basic material alarmingly short was airplane dope, a varnish-like composition for coating the fabric on planes to give it a smooth, taut, waterproof, non-inflammable surface, resistant to the weather and also to oil and gasoline. Under the great demands of the new American programme, it was obvious that the supply, which had been short even for the Allies alone, would be wholly inadequate. Indeed, the

situation was so critical that a call was sent out for meetings of manufacturers and representatives of the British War Mission and the Bureau of Standards on November 13 and 20, 1917, which developed that only 106,000 long tons of acetate of lime was available to supply not alone airplane needs of the Allies and the United States, but also the Ordnance, Navy, medical and other departments' requirements of 170,000 long tons. All supplies were therefore commandeered by the War Department on December 28.

The story of dope is largely that of its constituents, especially acetate of lime, for which no substitute was available. The supply of this product, generally made with methyl alcohol in the distillation of hard wood, could not be increased by existing plants, which were already being run at capacity, nor by building new plants, as the supply of cut wood was largely exhausted and the use of wet or artificially dried wood was not successful. The one exception to this rule was the Tennessee Valley Iron and Railroad Company, which was advanced $1,102,000 to build a new wood distillery where the charcoal by-products would be a permanent asset in the iron industry nearby.

New sources, therefore, were imperative. First projected was the utilization of molasses, alcohol and vinegar at the United States Industrial Chemical plant at Baltimore, originally constructed for the British but not operating because of failure to agree on terms. Next was the use of the black liquor from pulp mills at two plants to be erected by the West Virginia Pulp and Paper Company with Government advances of $4,600,000. Third was the use of the waste of sawmills at a plant to be erected by the

American Wood Reduction Company with a Government advance of $1,800,000. Cotton-seed hulls and blighted corn were also developed as sources of acetate.

Other dope constituents were also badly needed, especially acetic anhydride, glacial acetic acid, and cellulose acetate. These materials were manufactured here on a small scale wholly inadequate to meet the demand, and the situation required investigation of very technical and intricate chemical problems, for which, fortunately, some of the very best specialists were available. On December 21, 1917, a meeting of representative manufacturers was held, and various other steps to assure the necessary production were taken.

By May 25, 1918, a total of 204,000 gallons of dope was on order from 10 sources created by the Government at a cost of $7,520,000, producing acetate of lime, acetone, methyl alcohol, glacial acetic acid, and methylethylketone acetate. Up to that time 108,135 gallons had been delivered, with a total for the final week of 5,210 gallons, an annual rate of 250,000 gallons. In the week ending May 31, 40,760 gallons were released to manufacturers, and 84,000 gallons were on hand to meet the June requirements of 80,000 gallons.

Another very important material that threatened to run short was castor oil, which alone, because of its not being affected by the gasoline slipping into the crankcase, could be used to lubricate rotary airplane motors. At the outset, moreover, it was expected that castor oil would be used in the Liberty Motor also, and a total of 3,000,000 gallons was reported to

Secretary Baker on October 12, 1917, as necessary above the 700,000 gallons in sight up to July 1, 1918.

Steps were immediately taken to safeguard the available supply of castor oil by an embargo on exportation and prohibition of its use in making transparent soap and other non-essentials. All that could be located about the country was bought up at a stated day and hour, roughly 190,000 gallons. In November an unexpected addition was secured through the purchase of 1,200,300 gallons of the 1917 Indian crop crushed at Hull, England. The greatest step, however, was the decision of November 2 to plant crops of castor beans sufficient to produce 3,000,000 gallons. Seeds were imported by a special ship which, although already loaded at Bombay, India, was released for this purpose by Great Britain and which arrived here on January 7. Arrangements had been made in the meantime to plant 100,000 acres to castor beans in this country, the Dominican Republic, Haiti and the West Indies, at a guaranteed price of $3.50 per bushel. Thus an industry which had previously flourished in this country but which had been killed by cheaper importations from India was restored on land ruined for cotton by the boll weevil or in orchards planted with citrus trees.

Later, but eventually more important, appeared the need for a satisfactory mineral-oil lubricant. Strangely enough little study had been given to the subject of engine lubricants, and the practice varied with each engine and manufacturer. About 22 different oils were in use at the different fields, some of them worthless after five to 10 hours' run. The

whole question of lubrication was so little understood that half a million dollars worth of planes were ruined by defective oil at Kelly Field. Hence arose the problem of developing a standardized oil, especially for the new Liberty Motor.

An oil survey of all standard types was begun on November 1, under direction of Captain O. J. May, an oil expert, who supervised 37 engine tests in 25 days in a laboratory supposed to have about half that capacity. From these tests, and from advice, suggestions and records supplied by all oil companies, present practices were found to be widely varying, with no allowance for the change in character of oil after even an hour's use. Altitude tests in particular were necessary, and these were made in a sealed room at the Bureau of Standards from which it was possible to exhaust the air to any degree desired. Here Captain May stood watch for 65 consecutive hours without sleep; shortly afterwards he took cold and gave up his life practically from exhaustion.

Captain May's work, however, survived in the new "Liberty Aero Oil," shortly announced as the Government standard. It was based on the necessity of providing a lubricant that would change in constitution as little as possible through the absorption of gasoline; that would leave the engine clean and well lubricated, with any objectionable carbon of a loose and flakey, rather than a hard and adhesive, character; and that would be capable of reclamation and reuse after removal nightly from the engines. It was estimated that the new oil, in addition to giving far greater engine efficiency, would save millions of

dollars through its use in the engines for which it was available, both because of an original cost one-quarter that of castor oil and because of the fact that 50 per cent. of it could be reclaimed and reused.

A problem far more complex and many-sided was that of the equipment, instruments and accessories required for every plane, totaling several thousand dollars in cost for each. These included the instruments to navigate the plane, the armament to make it an offensive and defensive machine, and the equipment to enable the pilot to go to great heights and to take photographs and send radio messages. When the development of the American programme began, practically none of these vital accessories was being produced here in quantity and most of them were not being produced at all. A large majority were developed from foreign models, which in turn were constantly changing and improving; the rest were adapted from American designs. An enormous amount of experimentation was therefore necessary.

In navigating instruments, for instance, there was the tachometer to show the speed of the propeller; the air-speed indicator to show the speed of the plane in relation to the air rather than to the earth; the altimeter to show the height above the ground; the radiator thermometer to show the temperature of the engine; the banking indicator to show the plane's relation to the horizontal; the Aldis sight for use in firing through the propeller; and the airplane compass, clock, gasoline- and oil-pressure gauges, and lights and flares for night flying. For the pilot there had to be provided apparatus, helmets and tank for oxygen to enable him to go above 15,000 feet altitude,

THE MOUNTING OF THE CAMERA ON BRITISH OBSERVATION PLANES

OBSERVER IN THE "CAMERA OBSCURA" USED ON BOMBING PLANES, IN WHICH, BY AN ARRANGEMENT OF LENSES AND MIRRORS, A PANORAMA OF EXTERNAL OBJECTS IS PROJECTED UPON A SHEET OF WHITE PAPER

safety belts to keep him in the plane during acrobatics, and electrically heated clothing to keep him from freezing in the rarified air. For radio work were needed receiving, transmitting, combination, and interphone sets; and for aerial photography, observation cameras, enlarging cameras, camera guns, and unit-section equipment. For offensive work were needed three types of machine guns, two types of interrupter gears for firing through the propeller, gun mounts, gun sights, gun yokes, and other accessories, as well as two types of incendiary bombs, six types of high-capacity bombs, two other types of bombs, and six types of bomb sights and releases. This armament, as it happened, was provided by the Bureau of Ordnance.

Very early it was realized that all these delicate instruments and accessories must be standardized, and the Signal Corps took over their supply to all airplane makers, thus providing one center of purchase and putting an end to the disorganization of the market by the Government and the airplane manufacturers' competing against each other. The Government thus established a monopoly in these lines, selling the instruments to the manufacturers at cost as fast as planes were ready for them. Fortunately, considerable free time was available while the planes themselves were being built, which allowed the mobilization of resources and a far greater standardization of types than prevailed in Europe. By the end of the first year quantity production had been reached for the simpler instruments and was in sight for the more advanced.

CHAPTER X

THE MANY-SIDED PROBLEM OF ENGINES

Engines the limiting element on expansion of the Air Services — Aviation-engine manufacture in the United States before the war — Engines for training planes — The OX5 and the A7A — The Hispano-Suiza — The Gnome and the La Rhone — Battle-plane engines the heart of the aviation problem — State of design at the time the United States entered the war — Efforts to adapt foreign models — The Clerget and the Lorraine-Dietrich — The Rolls-Royce — The Bugatti — The project for an all-American high-powered motor — Reasons for its adoption — The Liberty Motor designed — The first unit assembled within a month — The motor proved in tests — Choice of manufacturers — Difficulties of manufacture — The skilled-labor problem — Abandonment of the eight- and adoption of the 12-cylinder type — Its power under test — Production estimates and performance — Demands of foreign Governments and other American services — Causes of delays in production — Changes in design — Exacting and rigid specifications — Difficulties of inspection — Lack of tools, jigs and gauges — Lack of coal and difficulties of transportation — Development of new types of the Liberty — Its technical performance.

All through the war the great limiting element on the size of the various Air Services had been the difficulty of obtaining satisfactory aviation engines in quantity. Where it required six months to put a new plane without engine into production, it required at least a year to put the engine itself into production. Moreover, with every day that passed the difficulty increased with the relentless increase in power demanded of airplane engines.

Up to the time when America entered the war, the extremely light, very powerful aviation engine needed for battle-plane work had never been produced in

this country. Four companies, the Hall-Scott Company, the Curtiss Aeroplane and Motor Company, the Wright-Martin Company, and the General Vehicle Company, had produced aviation engines, but designed along lines of durability rather than great power combined with lightness, and adaptable therefore only to training planes. The problem, therefore, was a double one — first, to increase enormously the manufacture of existing types to meet the greatly expanded training programme, and second, either to develop here or adapt from abroad a wholly new type of engine for battle-plane work. The two elements of the problem were entirely distinct and should not be confused.

The story of training-plane engines is short, but deserving of more consideration than has been given it in the concentration of thought on the Liberty Motor. At the very first meeting of the Aircraft Production Board, on May 18, 1917, purchase was recommended of 700 Curtiss OX5 90-horse power engines for installation in the JN-4D plane, followed on May 24 by the recommendation of 1,000 Hall-Scott A7A 100-horse power engines for the Standard SJ-1 planes. These two planes, as it happened, had been selected as the best immediately available for training, and as they had been especially designed around their respective engines, the engine orders followed automatically. Additional orders were placed with these two companies to the limit of their capacity, and new sources were found in the Nordyke and Marmon Company, Willys-Overland, Incorporated, and the Wright-Martin Company. By the end of the first year a grand total of 7,950 OX5 and 2,250

A7A engines had been ordered, with 4,340 and 2,054, respectively, delivered. There was nothing spectacular in this work, but it represented a very sound enlargement of facilities which made possible the whole preliminary-training programme and tided over the time until the more powerful engines could be developed and put into manufacture.

Another engine, used for advanced training and later developed into higher power for battle-plane work, was the Hispano-Suiza. The Wright-Martin Company had just reached production on the 150-horse power type for the French Government when the United States entered the war. Some time was consumed in securing a waiver of the French patent rights, but as soon as possible, on July 7, 1917, an order was placed for 500, with another order when the French contract was finished on October 1. By May 23, 1918, 3,500 had been ordered and 1,685 delivered for use in advanced training planes, where greater power was needed than could be developed by the lighter engines.

Two other types of this engine were also developed during the first year but not produced in quantity. First was the 180-horse power engine for advanced training, of which 3,000 were authorized, and second, the 300-horse power engine, of which 300 were ordered for lighter battle-plane work than that of the Liberty Motor. The first two experimental engines of the second type proved successful and promised well for the series. Work on the Hispano-Suiza throughout, however, was handicapped by lack of data from France and the differences in metallurgical practice.

Here also should be mentioned two other engines,

the Gnome and the Le Rhone, both 100-horse power rotary motors. These the Allies asked shortly after our entry into the war to have manufactured here for them for use in advanced-training planes and light speed-scouts. American manufacturers, however, were loath to manufacture the rotary type of engine as they considered it impracticable and had seen every one who tried it lose money. The General Vehicle Company, as a single exception, had been producing 90-horse power Gnomes on a small scale, and the General Motors Company was induced after much argument to combine with them to manufacture 5,000 of this type. Just then General Pershing cabled that they were no longer needed, and as a result the combination was broken up. The General Vehicle Company, however, as the only organization skilled in this work, was kept intact for a time by small orders, and later, when financially embarrassed, it was practically bought up by the Government for about $1,500,000. Up to May 23, 1918, a total of 242 100-horse power engines had been ordered and 177 delivered, and work had been begun on 100 110-horse power engines for use in the Thomas-Morse single-seater pursuit-training plane.

The Le Rhone had a more checkered career. Three times the Union Switch and Signal Company agreed to take an order for 2,500 and each time asked to be excused. At last, in September, 1917, they set to work, but with very incomplete drawings and such inaccurate metal specifications that a complete new analysis had to be made. Production had just begun by May 23, 1918, with every promise that it would soon become appreciable and allow a considerable

margin over what were needed for the Thomas-Morse scouts to be shipped overseas.

We now come to the battle-plane engine situation, the heart of the aviation problem, a tangle of romance, extreme technique, abuse and praise, practically never as yet explained in full. Around this one element surged the great American hopes and the whole public discussion of the Air Service. Probably not for a generation will all the scattered pieces be fitted into the true mosaic of history.

The entry of the United States into the war found the aviation engine just ready to break forth into a great development. Whereas in August, 1914, 80 horse power had been the maximum, two engines had by now developed 275 horse power and for the engines being planned 400 horse power was anticipated. Nothing at the time, however, approached that power. Of the existing battle-plane engines, the Hispano-Suiza 150-horse power was being produced in the largest numbers, while the 200-horse power type was as yet unproved. The Clerget 130-horse power rotary motor was well spoken of, and the Rolls-Royce 275-horse power and the Lorraine-Dietrich 270-horse power engines were in small production. Obviously, this situation was not promising in view of the repeated cables that engines developing 400 to 500 horse power were needed. Moreover, 18 months was estimated as necessary to redraw European designs and begin production in American factories, for the fine hand tooling abroad was entirely different from standardized machine work here, especially as foreign specifications did not express the European system of "tolerances."

Nevertheless, steps were taken at once to put these foreign types into production. The Hispano-Suiza, already on order for France at the Wright-Martin Company, was increased to capacity. Negotiations were entered into with the French for patent rights of the Clerget and the Lorraine-Dietrich, which it required until June 30, 1917, to unravel. When at last the Clerget blueprints and specifications were received here, they were so incomplete that satisfactory results could not be promised; by that time also the low-powered motor had become even more out of date, and adequate arrangements had been made to have the Gnome and the Hispano-Suiza made here and other motors bought abroad. The Lorraine-Dietrich also was delayed until it was replaced by the Liberty Motor.

This leaves the Rolls-Royce, the only high-powered motor immediately available, which it was endeavored by every possible effort to have developed here. Claude Johnson, General Manager of Rolls-Royce, Incorporated, and a half a dozen of their foremost officials were received here, offered one of the best automobile plants, and encouraged in every possible way. During the summer of 1917, however, the Liberty Motor with all its capacity for quantity production was proved, while the Rolls-Royce offered an output of only 2,000 engines a year beginning eight months off. Consequently, on September 22, a decision was reached not to include the Rolls-Royce with its expense of $15,000,000 to $20,000,000 in the American programme, but to afford all facilities for its independent manufacure here if desired.

One other foreign high-powered motor must be

mentioned to show that the United States did not pin its whole faith to the Liberty Motor. That was the Bugatti, a 16-cylinder, 1,075-pound, 500-horse power engine just completing experiments in France, the machine introducing the novel feature of a 1.25-inch cannon firing through the propeller. Rights to this engine were secured, a sample was sent over, and 2,000 were ordered from the Duesenberg Motor Corporation. The motor, however, was found to be nowhere near so thoroughly proved as it was understood to be, and wholesale changes in design, some of them fundamental, were necessary. By the end of the year 1917 the greater part of this work had been done and production was expected to begin on a small scale within a short time.

Now comes the Liberty Motor, the central hope of the Air Service's friends and the storm center of its enemies, a venture truly American in its fearlessness, its speculativeness, its publicity, and eventually its carrying through. Offering in theory the one means of winning the war through the air, it was surrounded with the possibility of desperate failure and of certain condemnation. Nevertheless, its very boldness of conception assured it the support of all elements pledged to win the war.

The United States, faced by the double necessity of developing engines of much greater horse power and enormously greater volume of production than ever before attained, dedicated itself in the first six weeks of the war to the attempt to develop a standardized high-powered motor capable of infinite reproduction. The reasons were undeniably cogent once the possibility of success was admitted. The Allies

had allowed their manufacturers to scatter with 60 different engines and had arrived nowhere; the Germans had concentrated largely on one and had achieved good-sized production. The United States as a Government could assemble for the designers the best of all foreign and domestic experience, unavailable for the usual commercial competitive methods and practically unknown here. Moreover, the designing of a new motor here could be carried out more quickly than the adaptation of an existing foreign engine with all the differences in design and manufacture. The repair problem across the ocean could be met only by standardized, interchangeable parts, and horse power could be increased over the 150 maximum here and the 275 maximum in Europe to the 400 demanded only by the pooling of all resources and knowledge in one supreme, all-American effort.

Colonels Deeds and Waldon had just arrived at this conclusion when two of the country's foremost aeronautical engineers arrived in Washington. J. G. Vincent, who in the three years since the spring of 1914 had developed at an expense of about $400,000 a successful 242-horse power aviation engine for the Packard Motor Car Company, had come to propose a standardized motor. E. J. Hall, of the Hall-Scott Company, which had developed the aviation motor of that name, brought a wide practical experience and a complete knowledge of foreign engines. As it happened, these two men had never met. At once, however, the four motor experts got together, and on May 29, 1917, the proposal of a standardized, all-American motor was discussed at a formal conference with General Squier and others. Two days later the

two engineers presented detailed proposals to the Aircraft Production Board and the Joint Army and Navy Technical Board, which immediately approved the project. Thereupon Hall and Vincent shut themselves up in Colonel Deeds' suite in the Hotel Willard for five days of uninterrupted designing, at the end of which, on June 4, they brought out finished plans of the so-called Liberty Motor.

On June 6 the sum of $250,000 was requested by the Aircraft Production Board to carry on this development, and by June 30 a force of 30 draftsmen had been collected from the various automobile manufacturers, without charge, and set to work at the Bureau of Standards. Suggestions and criticism were freely given by many engine specialists, and trade secrets and processes were readily divulged in the striving for a perfect mechanism. As fast as designs for parts were ready, orders for their immediate manufacture were sent to 12 different plants best equipped to turn them out. By July 3, 28 days after the drawings were begun, these parts had been assembled at the Packard plant in Detroit into the first eight-cylinder model, and shipped on to Washington by special car in charge of four young men in the record time of 21 hours.

This engine was a composite of the best proved elements of engine design, with nothing new or experimental included. Blueprints of all foreign and domestic motors and the experience of the British, French and Italian representatives as well as American manufacturers were freely available. The Packard engine was strongly represented in the cylinder, cam shaft, and water belt; the Hall-Scott

in the cam-shaft drive, pistons, propeller hub, bore, and stroke; and other types in various other features. Almost from the outset there has been dispute over the credit for the main inspiration for the motor which bids fair to increase in intensity with its success.

The preliminary designing, however, was but the beginning. The exhaustive series of tests which was to follow proved out the principles of the engine even beyond hope, while necessitating, of course, some changes in details. Tests in August at 10,000 feet altitude at the summit of Pike's Peak, in snow, rain, wind, and hail, and in a special chamber of rarified air at the Bureau of Standards showed no weakness at high altitudes. On July 23 the first standardized eight-cylinder unit was run at the Packard plant, and on August 29 the first flight with a Liberty Motor was made; this first airplane installation later broke the American altitude record.

About this time arose the question of the choice of manufacturers. Obviously the extreme accuracy required precluded the employment of any concerns but those possessing the largest capacity and the most skilled organization, and these, for the very reason of their success, were loath to leave a safe for a very uncertain field. Nevertheless, contracts with the Packard Motor Car Company, the Lincoln Motor Corporation, and the Nordyke and Marmon Company were placed on September 1, the first of a total of 20,500 contracted for by November 1, and the assembly of tools, jigs and gauges begun.

The quality of the companies selected is interesting. The Packard Company, which had been doing experi-

mental work in aeronautics for three years, bore the brunt of the final experimenting. The Lincoln Motor Corporation had been organized and built its factory within three months through the interest of Henry M. Leland, who had developed the Cadillac car. The Ford Motor Company had a capacity for quantity production unequalled in the world, as well as a special cylinder process. The Nordyke and Marmon Company were proved motor manufacturers, and the Trego Motors Corporation had had experience in heavy aviation-motor experiments. In addition many other standard companies were engaged on parts. It is not extreme to say that the best motor-manufacturing facilities in the United States were enrolled.

That this was essential is shown by the fact that even these companies required at least a month to become proficient in the final assembly and test. The first six motors turned out by the Packard Company developed a tightness of fit that caused the parts to jam and break the engines beyond repair, and the same thing happened with the first four Lincoln engines. The operatives required much training to appreciate the fine degree of adjustment necessary, and the work became practically a tool-room job, requiring the most highly skilled labor, rather than an ordinary production job using ordinary mechanics. This condition greatly discouraged the manufacturers, and it was met only by establishing special training courses for workmen.

The labor supply, moreover, had been seriously drained. The draft, voluntary enlistment, and the sudden demands of the new munitions plants brought about as early as September a threatening shortage

THE LIBERTY MOTOR AT THE SUMMIT OF PIKE'S PEAK FOR ITS FIRST ALTITUDE TEST, AUGUST, 1917

OUTDOOR TEST SHED AT THE LIBERTY MOTOR PLANT OF THE NORDYKE AND MARMON COMPANY, APRIL, 1918

in skilled toolmakers, patternmakers and machine-tool operators which held up the work appreciably. The withdrawal of one man from an engine factory may involve a wholly disproportionate loss and weaken the whole organization. At one time it was feared that Detroit would be stripped of its essential laborers, and recourse was had to releasing skilled men already in military service. By the end of the first year a complete system of industrial exemptions was being established so that the Air Service might not be unnecessarily crippled in its weakest element.

With the placing of the first contracts began the long, hard, uphill road to actual production. It was not as though these companies could begin work at once in turning out Liberty Motors; instead they had first to go far back and assemble the tools, jigs, gauges, materials, and skilled labor for the work and greatly enlarge their plant facilities. Meanwhile also changes in design were found necessary in further experiments, which appreciably delayed the progress towards production. The most vital change of all was the abandonment in early December of the eight-cylinder type of the motor in favor of the 12. This resulted from a cable from General Pershing of July 13 and the relentless demands for increased horse power, together with the fact that the 12-cylinder type best suited the planes actually assigned to production. Nevertheless, it considerably upset the manufacturers, as the eight-cylinder type was simpler and was well along towards beginning production. The decision had to be changed about 10 months later when the need for this intermediate power developed.

The first experimental 12, completed on August 13, passed the 50-hour test on August 25 with the official report that "the design had passed from the experimental stage to the field of proven engines." The test was in a series of runs, the last two of 10 hours each, with no stops during runs and no adjustments between them. The motor developed 314-318 horse power and was plainly capable of an appreciable increase, which a month later was estimated to be to 445 horse power. On October 21 the first flight of the 12 was made with much satisfaction in a Curtiss flying boat, and on October 29 it was flown in a De Haviland-4, an American-designed and American-built motor in an American-reproduced plane.

After this sensationally quick start came months of inconspicuous, unseen organization and upbuilding of plants, with further perfecting of the motor. The first schedules of production were found to have been over-optimistic and the date of quantity production was further and further postponed. On November 1, 1917, for instance, it was estimated that 55 engines would be turned out in that month, 280 in December, 725 in January, 1918, 1,250 in March, 2,310 in April, and 4,800 in May. This gave a total to June 1 of 9,420, whereas as a matter of fact the total production to May 25, 1918, was but 1,110.

The development, although slower than expected, was not the less substantial and progressive. On December 8 the Packard Company turned out its first two machine-made motors; on January 30, 1918, the Lincoln Corporation turned out its first, and from then on progress was steady. On January 10, in answer to alarming rumors abroad that the motor

was a failure, three Liberties were shipped overseas, followed at intervals by others for demonstration purposes and for the design of planes to carry them when quantity production should be reached.

All this time foreign Governments were seeking contracts for delivery of the motor in large numbers, for their plane capacity far exceeded their engine capacity. Italy asked for 2,000 in November, later raising it to 3,000, and England asked for 300 on December 14, also later, on January 23, 1918, raising it to 3,000. France likewise was in the market, though awaiting final tests before actually contracting. The Navy Department on September 27 called for 7,000 motors for its heavy seaplanes in anti-submarine work, and the Bureau of Ordnance wanted over 1,000 for its tanks. Early in the production work, therefore, it became evident that the demands would be far greater than those of the American Air Service alone.

The delays in production that were to come were consequently all the more aggravating. To try to enumerate them all, to explain them, and to show their inevitableness would in itself require a volume which would be so technical as to baffle all but the engineer. The most important fact to bear in mind, perhaps, is that they depended upon no one major reason or line of reasons, but rather upon a general combination, including broadly both technical problems of design and industrial problems of manufacture.

A number of changes in design startling to the layman but not at all surprising to the engineer who has seen a new motor in its growing pains undoubt-

edly was one large cause. The Packard Company, for instance, reported that there had been 1,022 changes between September 4, 1917, and February 9, 1918. The Ford Company reported 949 changes to March 21, some parts being modified six or seven times, until they felt justified in saying that future changes would be ignored and that "we are going to shut our eyes and produce as we stand equipped today." This succession of changes, they wrote, "raises havoc with the morale of our subcontractors," so that "it would be suicide to put across any more." Nevertheless, it was admitted that improvements were constantly effected by these changes.

A large number of the changes were found in continued experiments vitally necessary to improve performance, facilitate manufacture, correct clerical errors, and widen material specifications; and an even larger number were suggested by the manufacturers themselves as their experience in production increased. The experience wholly new to American industry was early presented of all the different manufacturers getting together in weekly conferences, aiding and making suggestions to each other, and offering improvements in design or methods of manufacture. Undoubtedly the concentrated thought and effort of these actual leaders of industry not only spurred on the actual development of the motor, but also made it distinctly an all-American rather than a wholly governmental product.

The specifications, especially for steel, were felt by the manufacturers to have been made unnecessarily rigid, but in this connection it must be remembered that an engine more delicate than any ever before

built was required, and that it was better to lean to the side of safety rather than of speed of production. Undoubtedly, as knowledge and skill came with experience, it would be found possible to ameliorate many of these requirements and considerably accelerate production, but at the start it was deemed best to take no chances. The inspection of the materials and of the finished motors also presented difficulties, for there was in the United States no skilled force capable of doing this painstaking and judicial work. The manufacturers charged that they were being held up by incompetent, impractical inspectors with conflicting judgments and changing opinions. This difficulty also was largely unavoidable in the general confusion and shortage of skilled men.

One of the most serious causes of delay at the start was the lack of all the tools, jigs and gauges essential to the work. Indeed, it was estimated that production was held up 50 per cent. by this cause. Before the intricate parts of the motor could be turned out, an immense amount of the most accurate machinery had to be brought together and adjusted. That machinery could not be hurried but had to be developed with the utmost care. All through the first year shortages arose in various lines, notably in thread gauges, which could be secured only slowly and with the utmost difficulty. Trouble was experienced also with cylinder grinders, water jackets, spark plugs, and insulators, which well illustrates how far back into industry such manufacture must reach.

During the winter months of 1917-18 the coal shortage and transportation difficulties caused loss of time. Delay in receiving special alloy steels and other funda-

mental materials was marked during the winter congestion, and a number of plants were closed or crippled by lack of coal or gas under the order shutting down non-war factories. Here again the actual loss is difficult to figure, but undoubtedly it was serious.

Despite these and other causes of delay, however, a great industrial foundation began gradually to form, and attention was turned to other types of the Liberty. It was apparent that the 12-cylinder could not supply all engine needs for all types of planes, that it was too heavy for the single-seater speed-scout, and later that it would be surpassed in power by engines then in the development stage. Consequently a series of experiments were carried on until six different types of Liberties were in contemplation. By mid-April of 1918 two sample four-cylinder engines had been built and proved successful; two sample six-cylinders, especially for a series of engines for heavy bombers, had been ordered; the eight-cylinder was again in development thought felt to be difficult to build a plane about; and besides the 12-cylinder direct-drive, two geared and one duplex 12-cylinders had been built, both to develop over 500 horse power. Thus the Liberty principle bade fair to answer a series of widely different requirements on a standardized, quantity-production basis with a single stream of repair parts.

During the first year, moreover, the technical development had been very gratifying. Rated at 314 horse power in the initial tests, the 12-cylinder Liberty had risen to 395 in October and to 450 at 1,800 revolutions per minute by May, 1918. This, with a weight of 825 pounds, gave a power of 1.8 horse

power per pound, making the Liberty the lightest engine per horse power in the world. The fuel consumption of 0.5 pound per horse power was also very low. During the year serious troubles in ignition, radiation, carburation, and lubrication were overcome; the latter required a let-up in production for over a week in March and the substitution of a forced-feed for a scupper system.

It is not too much to say that the Liberty Motor by the end of the first year had proved itself by every test it was possible to put it to in this country. Despite the storm which beat about it, the manufacturers who were making it and the foreign Governments who were relying upon it stood strongly to its support. Within less than 12 months quantity production of an engine developing over 400 horse power had been achieved and a rate of output reached five times that of the Rolls-Royce with only a small part of the organization in production. The first needs of the Army and the Navy had been met and the first motors sent to the Allies overseas. Mr. Ryan, who was later to take over all this work, said: "There is no motor on either side that compares with it."

Perhaps the story of the Liberty Motor may best be closed by the proud telegram from the Packard and Lincoln companies to President Wilson on May 17, less than 12 months after the first conference:

> We announce with solemn thankfulness that yesterday marked the completion and shipment of the first thousand Liberty engines. The period of essential preparation is bearing fruit. Within the year, designs have been completed, equipment provided, the motor perfected, and quantity production achieved.

CHAPTER XI

THE DEVELOPMENT OF PLANE CONSTRUCTION

Training and battle planes two distinct elements in the problem of planes — Primary-training planes — The Curtiss JN-4D and the Standard J-1 — Advanced-training planes — Adaptation of the JN-4D — The Thomas-Morse scout — Battle and bombing planes — Reasons for the discrepancy between expectation and accomplishment in their production — Lack of technical knowledge — Difficulties of communication — Lack of manufacturing facilities — Unexpected intricacy of the work — The best Allied planes chosen for American reproduction — The Spad — The De Haviland the mainstay of the American programme — Preliminary experiments and organization of manufacture — Complications between types "4" and "9" — Optimism and disappointments in regard to production — The first De Haviland-4's ordered overseas — The manifold problems of equipment — Production of "4's" at the end of the first year — Defects of the early planes — Continued development of the De Haviland-9 — The Bristol scout — Its redesign for the Liberty Motor — Its disappointing career — Night-bombing planes — The Handley-Page — The coöperative agreement with England — The Caproni — Its adaptation to the Liberty Motor — Plans for an all-American plane — Planes ordered and produced overseas — The situation at the end of the first year.

The problem of planes, like that of engines, divides itself sharply into two distinct elements, training and battle planes, both vitally essential but wholly distinct from each other.

When the United States entered the war, the overwhelming immediate need was for training planes to give primary instruction to the hundreds of cadets coming through the examining boards and the ground schools. At that time only one company in the United States, the Curtiss Company, was in any appreciable production, turning out about 100 planes a

month for the British. It was decided at the second meeting of the new Aircraft Production Board on May 18 to crowd this company to the limit, and a recommendation for 700 of their JN-4D type was accordingly made, with an additional 800 recommended on May 21. As the number of OX5 engines available for this plane was limited, another plane was necessary to meet the immediate training demands. The J type of the Standard Aero Corporation, built about the Hall-Scott A7A engine and then in small production, was selected, although frankly not so satisfactory as the JN-4D. Nevertheless, it helped tide over the early alarming shortage and kept the training programme from very serious embarrassment.

Even with these two main companies at work to their capacity, new sources of manufacture for primary-training planes were imperative. Less than a dozen other airplane companies were listed in the whole United States, and those merely small, experimental companies wedded to their own individual models and to hand work. As rapidly as possible, however, new orders were placed, and on May 25, 1918, seven companies were working on the JN-4D and four on the J-1, most of them new to airplane work but capable of large production.

Actual deliveries naturally came very slowly. The first was of six Curtiss planes in June, 1917, the entire output of the United States in the third month of the war. In July the number increased to 78; in August to 83; in September to 164; in October to 274; in November, with five more companies reaching production, to 394; and in December to 656. By the end of the first year 2,837 JN-4D and 1,600 J-1 planes

had been delivered, more than enough to meet the primary-training demands.

This leads us to the problem of advanced-training planes. Obviously these two primary planes with their speed of only 80 miles an hour and their lack of equipment could not fill the requirements of training in aerial machine gunnery, bomb dropping, formation flying, pursuit work, and single-seater fighting. The early expectation was that a series of foreign battle planes, notably the British De Haviland, could be manufactured here in time to begin advanced training in January, 1918, but that proved wholly out of the question. The JN-4D plane, therefore, had to be changed over, equipped with the 150-horse power Hispano-Suiza engine and as much special gunnery, bomb-dropping, and other equipment as possible, and used as a temporary makeshift. Up to May 25, 1918, 1,504 had been ordered and 501 delivered, all from the Curtiss Company, thus allowing some progress to be made in the advanced-training work.

For single-seater pursuit training a special plane was, of course, necessary. Considerable delay was involved in the decision between the Thomas-Morse scout, already in limited production here, and the British Bristol, highly spoken of in the cables but necessarily requiring another six months to reach production. The former was finally decided on in September, 1917, and by the end of the first year 500 had been ordered and 130 delivered, sufficient to meet a large part of the demand at that time, as most of this single-seater training was scheduled for France.

Now we come to the second element of the plane problem, that of battle and bombing planes, the most

THE CURTISS JN-4D TRAINING PLANE

complex of the whole Air Service, requiring not only far more manufacturing facilities than the training programme, but in addition a wealth of scientific knowledge that was wholly lacking. It must be borne in mind that these two problems were quite distinct but nevertheless interacting on each other, and that they persisted with varying intensity throughout the whole first year.

The discrepancy between constant expectation and actual accomplishment in these programmes is one of the fascinating phases of the Air Service story, which can be appreciated only by an intensive study of a maze of dates and details. Roughly, four cardinal reasons were responsible: America's utter lack of knowledge of battle planes, the total absence of facilities to manufacture them, the distance from the front with all the difficulties of communication, and the wholly unsuspected intricacy of the problems involved.

At the outbreak of the war no one in this country had any adequate knowledge of what a battle plane actually was. Not only had none ever been built here, but only a handful of technically trained Americans had even seen one. Their secrets had been guarded by the belligerents with the utmost care, so that the information from the military attachés abroad was negligible as a basis for reproduction of mechanisms so highly complicated. This was doubly unfortunate in that it concealed the true compexity of the problem.

The difficulties of communication with Europe and the confusion of cabling complicated the situation immeasurably. With the first nine weeks of the war occupied in the preliminary organization and in map-

ping out the enlarged programme, Colonel Bolling's technical commission did not sail overseas until June 17, 1917. Naturally considerable time was required for them to gain the confidence of foreign officials, to weigh all the conflicting claims abroad, and prepare definite recommendations to this country. The outstanding fact is that four months elapsed from our entry into the war before the first De Haviland model arrived in this country, and five months before the first Bristol arrived. Thus over a third of the first year was consumed in the mere physical task of getting foreign planes and plans to this country.

Once here their duplication was complicated by the utter lack of engineering and manufacturing facilities. Airplane designers and engineers familiar with European battle planes were practically non-existent, and the inadequate physical facilities are shown by the fact that the De Haviland was adapted to American reproduction as the factory was being built over it, and the work on the Bristol took place first in an unheated sheet-iron hangar and later on the main floor of a crowded factory. Furthermore, the preparations for manufacture necessitated the construction of practically new plants and the assembly of a class of labor and a kind of material seldom before brought together.

The intricacy of the work was its most unsuspected pitfall. The extreme accuracy of workmanship, the delicacy of balance, the consideration of such details as whether escape was allowed for heated air in the wings, all combined to create a series of interrelated problems which paralleled no experience in this country. Worst of all was the equipment, all the

navigating instruments, armament, and the like, constantly changed by cable and constantly requiring readjustments and modifications.

The best way to appreciate the difficulties met and the rise and fall of hope is to retrace the history of the separate types. Here it may not be amiss to state that the United States did not base its programme on any new, capricious developments but adopted the best Allied planes. The De Haviland, Bristol, Handley-Page and Caproni were taken over bodily, subject only to such changes as were necessary because of American manufacturing methods and the installation of the Liberty Motor. Their selection was agreed upon by a technical mission to Europe, the Allied aviation missions here, and the Joint Army and Navy Technical Board.

Take first the case of the Spad, the famous French single-seater scout that was making such an enviable record at the front and that later became a storm center in the American programme. This plane was decided on for American reproduction, a model secured, a contract let to the Curtiss Company on September 19, 1917, for 3,000 planes, a large force of draftsmen set to work, the drawings 90 per cent. finished, materials collected and work about to begin, when the following cablegram from Colonel Bolling on November 8 upset the whole programme:

> Single-seater fighters will probably become obsolete general use next year, although small number will always be used for special purposes. Recommend you produce number already under contract and started. Believe we can obtain here all this type required future above number actually contracted here and America.

The Curtiss work was immediately interrupted and some time spent in seeking the best way out. Colonel Deeds cabled the suggestion that the Spad bodies be built here with engines installed in France, but General Pershing on December 15 flatly opposed this plan, saying, "United States should leave production of single-seater fighter to Europe." Thus, on definite orders from overseas, the fast single-seater scout was abandoned, with all the work that had gone into it, the number thought necessary ordered in France, and the Service laid open to the bitter charge that it was building no "battle planes."

The De Haviland two-seater combination fighter and day bomber was from the start the mainstay of the American programme. This plane had been adopted in the first Joint Army and Navy Technical Board programme of May 22, endorsed by Colonel Rees of the British Mission on June 4 as "the latest word in bombing machines," recommended by the American technical mission to Europe in cables of July 13 and 31 and August 7, and included to a total of 8,000 in the first manufacturing programme of August 2.

Four months, as stated above, elapsed before the first De Haviland model arrived in this country, and it did not actually become available for American production until it reached Dayton on August 26. The drawings accompanying it were very meagre indeed, and no information was at hand about balance or equipment. These conditions, with the necessity of adapting the plane to the heavier Liberty Motor, necessitated the construction of an experimental model. This first American-built De Haviland with

the new Liberty Motor made its first flight on October 28, two months after the work of reproduction had begun. Both engine and plane functioned well, and the promise of very early and quick production seemed well grounded. Rapidly as the work to date had gone, however, it was unfortunately far more preliminary than was suspected, and it gave rise to hopes which later complexities were to destroy.

Meanwhile, manufacturing sources were being secured. The Dayton-Wright Company, which bore the brunt of the experimental work, was recommended by the Aircraft Production Board on September 5 for a contract to build 2,000 De Havilands, the " go-ahead " on the first 250 being given on October 18. The Fisher Body Corporation, one of the largest automobile-body makers in the world, were shortly secured as a second source of manufacture with a contract for 3,000, so that facilities for very large production, once it had got under way, were assured.

The situation all during these early winter months was further complicated between the De Haviland-4 and the De Haviland-9. The latter, a more advanced model in development in England, was adopted in all the early American programmes here while the "4" was actually being redesigned. The British, however, met one disappointment after another with this type, which was necessarily reflected in its continual postponement on the programme here. On September 27 the American mission abroad answered a cable from here that 2,000 " 9's " were in the programme with the statement that, although no tests of that type had yet been made overseas, the number should be doubled. In mid-September very meagre

" 9 " drawings arrived, leading to a cable that the new programme included 6,000 of that type with shipment beginning in November. On October 17 the mission abroad urged that the number be increased to 8,000, but on November 13 it was found necessary to cable that as the sample " 9 " and the completed drawings had not arrived, work was going ahead on the " 4 " in order to secure production of something. This brought the answer that the British model had not yet been completed, and it was not for another two months, on January 5, 1918, that the drawings actually arrived.

Optimism for the " 4 " meanwhile was running high. On November 30 a programme was sent to the manufacturers requiring 50 planes in January, 1918, 350 in February, 1,100 in March, and 1,800 in April. In December a cable was sent: " Everything seems most promising. Expect to ship first De Haviland-4 complete January 15. Its performance excellent. Have had 120 miles an hour." On January 3, 1918, despite delays, a total of 1,475 De Havilands was predicted by cable to be ready for shipment by April 1. From this date, however, the really fine work, with all its adjustments and balances, began, and the schedule slipped further and further back as each unexpected difficulty cropped up. Warning was cabled overseas on January 26: " De Haviland-4 just barely in production. Schedule will fall below estimates previously given you." How serious this was may be seen from the reply that it was essential to rush shipments as the contracts for battle planes in France and Italy had been practically wiped out by local dangers.

At last on January 30, 1918, four De Havilands were ordered overseas, which led to the War Department's unfortunate statement that American battle planes were *en route* to the front. Only one of these planes was actually shipped, however, because of lack of synchronizing devices. This plane left Dayton on February 5 but was not floated at Hoboken until March 15. But despite the constant delays, optimism was felt that as the first planes had come through, large-scale production would shortly follow.

In mid-February the whole schedule was once more thrown entirely askew, this time by a very detailed letter from General Foulois on every phase of the equipment and armament. As one of the engineers wrote:

> All matters in connection with the De Haviland-4 had already been settled and full information sent to Dayton-Wright on January 31, more than two weeks before, so that a practically new start had to be made, and all, or practically all the work done previously altered or changed in such a manner as to cause a very serious delay.

This whole matter of equipment was summarized thus by Colonel Vincent:

> People ordinarily think an airplane is composed of a plane and an engine, but the big delay in getting out military airplanes in this country has been due to lack of equipment rather than planes or engines. I believe the De Haviland-4 could have been in production by January 1 if they had had complete information regarding equipment by the first of October.

An indication of the care and attention to detail necessary may be had from a letter from the British Mission on March 11 that the following requirements

found essential in British experience were changed in the American De Haviland:

> Aluminium washers are being used instead of steel; air pressure is being used for the gasoline system; cable is being used for interplane bracings instead of stream-line wires; storage for cutting off ignition is not provided in rear seat; rudder control wires are not duplicated; altitude corrector is not being used; radiator shutters are not fitted.

While these changes were being made, another serious difficulty arose with the overheating of the radiator at high altitudes. To illustrate the vicious circle of airplane construction, if a radiator satisfactory on the ground overheats at altitude and has to be changed, the new radiator will very probably be of a different shape or weight and require in its turn a complete alteration of the fuselage and balance of the plane. By March 28, however, the Ideal radiator had gone up 21,000 feet in one hour to a temperature of eight degrees below zero Fahrenheit without boiling, and the Livingston radiator had answered all requirements.

Finally, on April 8, 1918, one year after the United States entered the war and seven months after the first De Haviland model arrived in this country, the first fully equipped military plane flew with four machine guns, bombs, equipment, camera rack, oxygen apparatus, and heating generator, and on the same day it was finally decided that no further changes in the first 2,000 planes should be made. Just as an indication of the complexity of the work it is interesting to list the various subjects covered in a 12-page report in a conference on this date:

AN AMERICAN-BUILT DE HAVILAND-4 BATTLE PLANE

Special fittings
Camera mount
Tail light
Battery box and telephone control
Shutter underneath camera
Wimperis bomb sight
Camera operating handle
Trapdoor for above
Oxygen nipple
Joy stick
Wireless
Air-speed indicator
Aneroid
Oxygen tubing
Oxygen bottles
Battery box for telephone receiving set only
Gasoline tank
Bonding
Reinforced cowling
Livingston radiator
Radiator shutter
Oil lead to synchronizer generator
Aluminium heel plates
Altitude adjustment
Synchronizing reservoir
Oxygen-helmet connections
Elevating wheel
Cartridge chutes
Upholstering
Pilot's seat
Radiator
Very pistol
Oxygen apparatus
Holt flare
Generators
Ignition switch
Tail
Splice in fuselage
Magazine rack for lewis gun
Interphone box
Scarff mount
Doors on side of fuselage
Negative lens in gunner's cockpit
Clothing-heating plug
Telephone plugs
Gunner's seat
Antennae reel
Radio box
Lights for instrument boards
Camera plate holders
Filter boxes for wireless
Bomb-dropping lever
Spark and throttle controls
Exhaust pipes
Wiring
Engine controls
Propeller
Front brace wire fitting
Sperry compass
Fire wall
Instrument board
Front stick
Battery box
Gun brackets
Pilot's safety belt
Front and rear windshields
Shutter control for radiators
Fire extinguishers
Negative lens in pilot's cockpit
Wing lights
Low-tension ignition
Wing bonding
Aileron pulleys

Bomb-dropping rails	Shock absorbers on wheels
Wires between wings	Wing skid
Water-pump suction line	Overhead gas tank
Oil tubes under oil tank	Veneer sidewalk on wings

Production even now, however, did not go as fast as expected. It was found necessary to design a new type of bomb gear to handle the American style of bombs and a pilot's cowling and gun support for the Marlin guns, together with the synchronizing mechanism and its attachment to the Liberty Motor. The design, location and installation of certain of the equipment required a wholly unexpected amount of time, especially the radio and telephone sets with their generators, brackets and instruments, the lighting and heating apparatus with generator, brackets, lights, wiring and heated clothing for the aviator, and all the paraphernalia for oxygen supply at high altitudes.

Nevertheless, by the end of the first year the De Haviland-4 was in appreciable production. In the week of May 25, 1918, 48 were turned out with the Dayton-Wright Company alone in production. Up to that time 155 had been delivered, of which 133 had been sent to Hoboken and 49 actually floated overseas, and the promise of fast production from then on was certain. The first American-built De Haviland, with the Liberty Motor, took the air in France on May 17 and was reported as "entirely satisfactory." Apparently the planes stood the shipment overseas well, giving assurance that the work done in this country was well done. If production were several months behind expectation, nevertheless the De Haviland-4 seemed to prove that the great major problems of

securing scientific knowledge and of building up an industry were overcome.

This by no means signifies, however, that the De Haviland as then produced was a complete success. On the contrary, the first several hundred produced were bitterly criticized by different fliers for different reasons. The radius of flight, only about two hours, had to be increased by the use of a much heavier gasoline tank. The seating of the pilots was poor alike for observation, bomb dropping and machine gunnery, all of which defects were remedied in the "9" type. The tail was weak, the linen subject to ripping off, and various parts not well balanced. But all these difficulties were open to remedy, and the basic soundness of the plane was shown in General Pershing's request that it be placed on the priority list for overseas shipment.

The "9" type meanwhile was developing rapidly. Despite all the vexing early delays in securing a model and plans, when at last they came they were complete. As one of the designers said, the De Haviland-9 was "the first military airplane ever redesigned in this country with the necessary information on hand to enable the job to be done." As soon as possible without delaying production, this type was to be substituted for the "4."

The Bristol battle plane was far less successful. Designed as a two-seater pursuit plane with two machine guns and the maximum amount of vision for the pilot, this type had been very successful with the British. It was recommended for the American programme in the cables of July 13 and 31 and August 7, and appeared in the first schedule of

August 2 to the number of 1,000. But four months and one week elapsed after America's entry into the war before the first model left England, with another three weeks before it reached Washington on September 5.

It was at once seen that the machine would have to be largely redesigned to carry the Liberty Motor, which was very differently shaped from and weighed 165 pounds more than the 200-horse power Rolls-Royce for which the plane had been planned. Indeed, the greater length of the Liberty and the carrying forward of the center of gravity required the whole engine-suporting structure to be changed and the wing area to be increased. The drafting facilities for this work were very bad; at first only three or four draftsmen were on hand, but they increased later to 35 or 40. During October, moreover, the sheet-iron hangar beside the Smithsonian Institution where the work was done was uncomfortably chilly, and relief was obtained only by curtaining off half the building and putting in oil stoves and gas heaters. The British drawings which accompanied the plane were found to be useless, as they were half British, half metric system, and gave no details of equipment.

The Curtiss Company was early selected as the manufacturer of this type, and the original model was sent to them on November 6, though without the power-plant parts and with incomplete Signal Corps prints which not until November 27 gave enough data for the construction of a model. During December the remaining prints were delayed at Dayton by other work, and it was not till January 11, 1918, four months after the plane had been received here, that

the final prints, so far as the Signal Corps could carry them, were delivered. Meanwhile, Colonel Clark, who had developed the plane so far, was taken off the work, and the Curtiss Company was largely entrusted with fulfilling it.

Here again early hopes ran high. A cable of September 22 predicted the first shipment would be in January, 1918, and another of January 3 forecast 300 planes by April 1. This estimate was more than halved, however, in the schedules placed in the shops on January 16, which called for 25 in February, 100 in March, 175 in April, 300 in May, 450 in June, and 475 each in July and August.

The period of changes and difficulty with equipment was now on. On January 27 many changes were ordered and anxiety was expressed because of lack of wireless, camera, and other accessories. On February 16 came General Foulois' letter, upsetting the whole armament and equipment programme and moving back the schedule another month. The designing was delayed, moreover, by the Curtiss Company's attempt to do the delicate reproduction work on the open floor of the main factory.

At last came the time for test. After some delay, arising from a poorly aligned tail skid, the drilling out of the holes for hinge pins on the wing beams by spies, and too much oil in the engine, the first short flight, five minutes in length, was made on March 5. Here, as all through the Bristol's career, the facilities were bad, there being no spare parts, portable tools, telephone, or heating at the field hangar. No further flight took place until March 22, when the plane was up 15 minutes. On the 24th a flight of 57 minutes

was made, with an altitude of 15,000 feet and a speed of 121½ miles an hour. Three days later the "go-ahead" was given on the first 25 planes; on March 28 the number was increased to 400, and on April 4 an estimate of 525 by June 30 was cabled overseas.

The plane, however, was not yet satisfactory. The redesign for the Liberty Motor and American equipment had not yet been fully worked out. Indeed, it became necessary because of rumors reaching the American Expeditionary Force to cable on April 13: "Tests so far made cast some doubt on its quick manœuvring ability. Judgment should be withheld, however, till tests have gone considerably further." A possible solution of these difficulties had been hit upon in changing over from the Liberty to the Hispano-Suiza 300-horse power motor. On March 16 the first test flight of this new model was held at Dayton; an altitude of 22,000 feet and a speed of 125 miles an hour were reached. This motor, however, was very slow in production, and another effort was decided upon in substituting the eight-cylinder Liberty for the 12.

By the end of the first year, after losing five months in getting the Bristol to this country and much more time through poor facilities in the Government and the Curtiss shops, the American Bristol was still unproved. All the way through, as one man expressed it, the Bristol had needed a friend. A great amount of work had been done, but it still remained to be shown whether the plane would be serviceable with the eight-cylinder Liberty or the Hispano-Suiza motor. Later it was found necessary to abandon entirely the

thought of putting the 12-cylinder Liberty in the Bristol. Whereas the original Bristol plane had weighed 2,910 pounds, the American reproduction weighed 3,360. The plane was weak in many particulars and eventually cost the lives of four pilots. Not only was much time lost and part of the Curtiss Company's facilities kept idle, but $6,482,000 was spent on this work, only a part of which could be salvaged.

The heavy night-bombing machines, such as the Handley-Page and the Caproni, represent a later development than the battle planes. At the time the United States entered the war, they were still in an experimental stage abroad, with their tactical value unproved. The Italians alone had demonstrated their practicability with the Caproni, while the British were experimenting with the Handley-Page, the French with the Letort, and the Russians with the Sikorsky.

The American technical mission to Europe ran full into the midst of this uncertainty and indecision, which was reflected in a series of conflicting cables as between the Handley-Page and the Caproni. On November 10 a cable read: "Advise concentrate your efforts on Caproni without regard to Handley-Page, because not in position send Handley-Page machine and preferable adopt one type night bomber." Then, by contrast, on November 22 another cable read: "Recommend withhold further consideration of Caproni until we obtain complete drawings night bomber from Caproni or elsewhere designed for Liberty engine making substantial advance over present Handley-Page."

The Handley-Page plane was first proposed to the United States in May, 1917, a few weeks after the

outbreak of war. A representative of the company endeavored to sell the rights to the White Motor Car Company for £40,000 and later to the Government for $250,000 and one per cent. royalty. Inquiry developed that the British Government had not taken much interest in the type as then developed, and after some trouble with the British Secret Service, the offer was withdrawn on August 11. By September, however, negotiations for a later type had been carried through successfully on the other side, and early in the month the first set of plans arrived in this country. Die makers were at once set to work and a big start made, when in mid-October a second set of plans arrived cancelling the first. The work on these was almost completed when a third set arrived on December 29, together with seven Handley-Page experts, requiring a third start to be made.

Meanwhile, with this type definitely proved in actual service and night bombing accepted as one of the really new elements of warfare, negotiations were on foot in England for assembly of American-built parts there on an enormous scale. On August 23 Handley-Page had proposed a large assembly plant in France, and on December 5 came the cable that an unlimited number could be assembled in England. Finally, on January 28, 1918, came the famous Handley-Page agreement, whereby the two countries were to coöperate to furnish 30 American Handley-Page night-bombing squadrons. The United States agreed to supply all parts and motors, 12,000 laborers to built the five airdromes and three acceptance parks necessary, and the operating personnel, and England agreed to furnish the factories and skilled labor for

assembly of 150 planes a month. This was to cost $5,000,000 for construction, $4,000,000 for plants, and $300,000 monthly for assembly.[1]

This, of course, greatly stimulated the Handley-Page effort here, and made the selection of plants a very important matter. After considerable discussion the Grand Rapids Airplane Company was recommended on March 14 for an order for 1,000 wooden parts, and the Standard Aero Corporation on March 19 for the metal parts and assembly of 500 sets. Thus, by the end of this first year the Handley-Page had been definitely established. Plans and engineers had arrived from England; the first plane was all but ready to fly; sources of supply were secured and set to work; and an agreement had been made for wholesale assembly in England. From now on it was but a matter for development, with the possibility that the steps already taken might become among the most vital in bombing Germany out of the war.

The Caproni made an earlier start than the Handley-Page, not only because the plane itself was further developed, but because the Italians had the good judgment to send two of the planes to this country for demonstration. When the two monsters, a triplane and a biplane, flew from Hampton Roads to Washington early in September, 1917, the sensation they created was reflected in the Aircraft Production Board's approval on September 5 of a proposal to build 250 of them.

Meanwhile the American mission had gone down into Italy, made a long flight to the front, and been

[1] Further details of the development of this project are given in Chapter XVI.

very much surprised at aviation developments there in contrast to what they had been led to expect. They were enthusiastic about the Caproni and recommended its manufacture here. Shortly, however, the Handley-Page demonstrated its value, while much difficulty was experienced in securing Caproni plans. On November 22, therefore, they cabled to hold up the Caproni until proved superior and until complete plans were secured. A few days later, on December 3, came an important conference at Paris with Caproni representatives, who proposed that they establish at Bordeaux, France, a huge assembly plant for 1,000 American Capronis monthly, manned by 25,000 refugee Italian workmen who were to be trained at the Caproni plant at Milan at the rate of 1,000 a month, under an agreement to give Caproni a small profit in lieu of royalty. The plan was then discussed of large-scale assembly of the Handley-Page in England and of Capronis in France, which would meet the critical shipping shortage and the urgent need for hundreds of night bombers.

Arrangements were then made to send Captain U. V. d'Annunzio, director of the new Caproni plant at Taliedo, to the United States. Signor Caproni, in his letter of introduction said: " We believe firmly that only the United States will be able to accomplish, by means of the materiel, etc., at its disposal, the big question of aerial bombardment." He also added: "I do not wish that any modifications whatsoever, *even in the slightest detail,* be undertaken by the American manufacturers *without formal permission from the engineer d'Annunzio."* Captain d'Annunzio, with 19 engineers, two sets of Van Dyke

LAUNCHING OF THE "LANGLEY," THE FIRST AMERICAN-BUILT HANDLEY-PAGE BOMBER, AT ELIZABETH, NEW JERSEY, JULY 5, 1918

drawings and three sets of blue prints, and a 600- and a 450-horse power plane, with parts, samples, and stamps for reproduction, the gift of Italy to the United States, arrived in New York on January 17, 1918, and began work on January 25 at the Standard Aero Corporation plant at Elizabeth, New Jersey, which had replaced the Curtiss Company for this work, on an experimental machine with three Liberties, a speed of 100 miles an hour, five hours' flight, and a useful capacity of 4,600 pounds.

On December 4 Italy had requested 2,000 sets of Caproni parts, 3,000 Liberty Motors, and 5,000 tons of Austin steel, but on March 20, 1918, General Tozzi canceled the order because deliveries were not due until July. It was then proposed to drop the whole Caproni project, but this was not done because of the appeals from overseas for all night bombers possible, the endorsement of the Joint Army and Navy Technical Board, and the progress made and the expense incurred by Captain d'Annunzio.

Finally, on April 10, at a conference in Washington, the definite decision was made to build the Caproni in quantity, this ending the uncertainty. Shortly verbal orders were given the Fisher Body Corporation to prepare for 250 Capronis, with possible increase to 1,000, on promise to start delivery five months after 90 per cent. of the plans had been received and to reach a production of 10 a day. Thus at the end of the first year the adapted American Caproni was just on the verge of being completed at the Standard plant, quantity production had been arranged for, and preparations for assembly in France were being made.

As all these foreign types were being adapted to American production, considerable experimental work to turn out an all-American plane was under way. The United States, assured of very good foreign types, had reached the point where it was possible to develop its own. With the Liberty Motor proved, attempts were being made to build new types of planes about it, a problem in a sense simpler than trying to adapt an existing type. The plans included armored planes, planes carrying cannon, fighters, observers and bombers, and they reached a high state of development during the year, with every promise for the future.

All this work in the United States does not, however, exhaust the plane programme.. The American mission had placed orders overseas to the limit of the available facilities, so that if American factories failed utterly, there would be a very appreciable supply of the best Allied planes.

First, of course, was the need for training planes for the hundreds of cadets in France. A total of 2,279 were on order by April 30, with 1,264 delivered. This was far less than the number needed and accounted for the long period of inactivity of so many of the cadets sent overseas. The French factories had been strained to the limit to meet their own programme and supplied the unparalleled flood of American students as fast as possible.

Of battle planes 5,816 were ordered, enough for a very large programme. This included 2,000 pursuit and 1,500 observation Spads, 1,000 bomber and 500 observation Breguet, 500 S.I.A. Italian day bombers, and 200 Capronis. Unfortunately, the deliveries here

also were very late, the French because Germany's accelerated programme called for a great increase in France's own force, and the Italians because of the Caporetto defeat. As a matter of fact, only 271 planes had been delivered on these orders up to April 30, this showing that others besides the Americans were having difficulty in meeting their programmes. The value of these planes, however, was very great, as they allowed the first American squadrons to appear on the front.

Thus in the first year of war the United States had adapted successfully three of the best foreign types, the De Haviland, Handley-Page, and Caproni, and had failed with the Bristol. The first-named had reached quantity production and was being shipped overseas. An industrial organization capable of unequaled production had been built up and all the technical experience of the Allies in three years of warfare acquired, so that America could begin independent development. Very large assembly facilities had been arranged overseas and large orders placed there. If accomplishment was enormously behind expectation, the groundwork laid was none the less thorough.

CHAPTER XII

DISRUPTION AND THE NEW START

Freedom of the Air Service from criticism during the first ten months — The Service first involved in the general attack on the war administration — The War Department's unfortunate announcement of shipments of American planes — Difficulties within the Air Service — Investigations ordered by the War Department and the Aircraft Board — The Service on the defensive — Public confidence destroyed by indiscriminate attacks in the press and in Congress — Charges of Gutzon Borglum — Headlong disruption under way — The first reorganization under John D. Ryan and General William L. Kenly — Investigation demanded — Borglum discredited — Charles E. Hughes selected to coöperate with the Department of Justice — The final reorganization — Bureau of Aircraft Production and Division of Military Aeronautics created — The first Air Service administration completely obliterated — Estimate of their difficulties, failures and achievements — Mr. Hughes' findings — Unfulfillment of early hopes and promises — The unforeseen difficulties, physical and human — The substantial achievement — Production of training and battle planes and engines — Production of raw materials and accessories — Personnel of the Air Service — Training of pilots, observers, and other officers — Training of the ground force — The force overseas — The situation at the new start.

For practically the first ten months of the war the Air Service was curiously free from criticism. As far along as January, 1918, when the great billion-dollar Air Service estimate submitted by General Squier for the fiscal year 1919 was before Congress, there had been a remarkable absence of trouble — this, too, despite the fact that the political situation was highly electric, that Secretary Baker was being hard pressed, that Senator Chamberlain had charged the Government with a general breakdown, and that President

Wilson had accepted the challenge of his critics by refusing to support the War Cabinet or Ministry of Munitions bills. Aviation, indeed, had from the outset been highly favored, as was shown in the passage of the $640,000,000 bill without a roll call. In a sense a rather anxious feeling had grown up that America's good name was bound up in its success, and consequently no one cared to contemplate its failure. Moreover, the Air Service appeared largely civilian in character, and as it was somewhat set off by itself from the rest of the War Department, it did not offer so good a mark for criticism. At the same time the upheavals in the Ordnance and Quartermaster's departments kept attention focused elsewhere.

What criticism there was in the Congressional hearings during January and early February followed two main lines. First was that seeking to draw from the work of the Air Service instances of the general breakdown of the war administration, as in overgorging the railroads with indiscriminate priorities, concentrating all contracts within one cramped area, or being uncoordinated with the rest of the war work. The other related to individual contracts or fields, either because they had been carried out injudiciously or because they had not been carried out as desired. On the vital problems of the Service itself neither knowledge nor interest was then shown. Rather startling statements by Colonel Deeds and Mr. Coffin that the aircraft programme was 45 to 60 days behind schedule aroused little discussion, even in the press.

Most serious, perhaps, was the situation in regard to Colonel Deeds and the insidious charges that because he was formerly President of the Dayton Elec-

tric Laboratories Company, general manager of the National Cash Register Company of Dayton, and an organizer of the Dayton-Wright Airplane Company, there was something criminal in the fact that the Wilbur Wright Flying Field, the McCook Experimental Field, and a large part of the battle-plane construction work had been located in his home city. With pressure being brought to bear on the *New York Tribune* to print these insinuations, Colonel Deeds laid the whole situation before the Senate Committee on Military Affairs, showing that when he had entered the Army he had written Secretary Baker and the Aircraft Production Board a full statement detailing and resigning all affected business interests. The Committee, after considerable grilling, became thoroughly satisfied and thanked Colonel Deeds for his explanation. Likewise the *Tribune* withheld publication, and the matter was dropped for the time.

On February 21 came the War Department's statement that the first American-built planes were "*en route* to the front in France," released on a day of scanty news and front-paged everywhere. Unfortunately, the whole purpose of the statement, first to show that planes had only then begun to go in small numbers, and second to explain the difficulties encountered and do away with the 100,000 airplanes myth, was entirely lost in a careless implication that American planes were five months ahead of schedule. Not only was the whole purpose thus perverted, but, more serious still, the facts themselves were found later to have been grossly premature. The same day also came an Associated Press story from France, surprising both for its editorial nature and for its

passing the censor, which said that German planes "come and go over the American lines almost at will," and asked desperately when American planes would be received.

Meanwhile matters were going ill within the Air Service. Mr. Coffin, greatly alarmed at the slow progress and growing rumors of criminality, suggested to Acting Secretary of War Crowell a complete investigation. On March 12, without warning to the Signal Corps, the War Department announced the appointment of an investigating committee headed by H. Snowden Marshall to "make a broad survey of the Government's aeronautical programme with particular reference to the industrial phases." At the same time the Aircraft Board announced that W. S. Gifford, Director of the Council of National Defense, would act in a similar capacity for the Board.

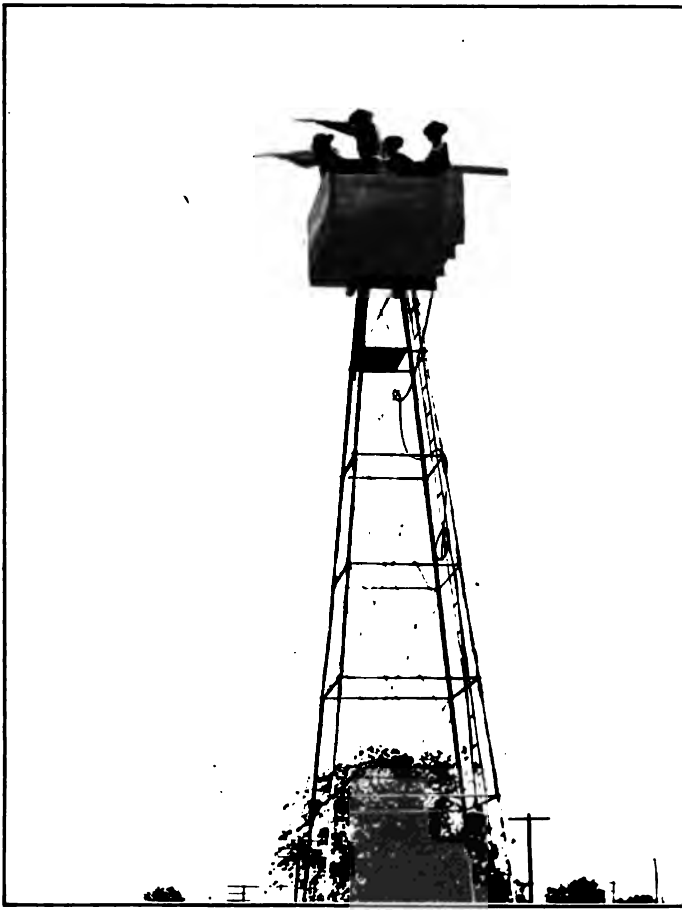
On the very next day came the most serious charge yet made against the Service. Following the first confidential conference between the War Council and the Senate Committee on Military Affairs, an Associated Press dispatch, widely featured, declared: "In some respects, the Senator said, notably in the aviation programme, there has been great delay and the War Council had initiated an investigation to determine the cause. Another member of the Committee said the aviation programme was 74 per cent. behind schedule and that over-sanguine reports were being inquired into." At the same time Senator Hitchcock issued a statement that "the aviation programme is bad; it is very far behind."

Thus for the first time the Air Service was put on the defensive. These statements, coupled with the

general confusion as to the Marshall and Gifford appointments, called forth a series of conflicting and haphazard newspaper stories which undermined the whole public confidence in the air programme and gradually mounted in sensationalism until the whole structure was swept away. It is doubtful if a more headlong breakup than that of the next few weeks ever occurred.

The *New York Times,* most relentless of all critics, reported that one Senator, on learning the true situation, "put his head on the committee table and wept from disappointment and chagrin." On March 18 the *Boston Herald* broke out into bold headlines: "Breakdown Threatens Vast Aircraft Programme — Congressmen Aghast." Other papers, half convinced almost against their wills, pleaded for a frank statement of facts that never came. A temporary respite only was secured by an Associated Press dispatch of March 16 that American-built planes, despite the delays, would be in France in sufficient force in July, when originally due.

The fact that only one battle plane had been shipped to France when the War Department issued its statement, was now confirmed officially. Hinted at by the *New York Times* and definitely stated on March 20 by the *Providence Journal,* it was admitted to be true by a Signal Corps officer testifying before the Senate Committee. This disclosure was very disastrous indeed, for it fell close on the heels of a growing distrust of the aviation publicity. Undoubtedly that announcement of the War Department was one of the worst mistakes made. Given out at the time the first De Havilands had finally come through into produc-



RIFLE PRACTICE ON CLAY PIGEONS FROM A TOWER, TO SIMULATE HEIGHT

tion and when four had been ordered overseas, it later developed that three were held in this country for further equipment, and that the solitary plane to go left Dayton on February 5 and arrived at Hoboken in sections some five weeks later. Secretary Baker personally was wholly ignorant of the details, and did not for a moment suspect that the Signal Corps officers who approved the story were straining with long-deferred hope and over-optimism.

And now, also, Gutzon Borglum, a personal friend of President Wilson, who since mid-January had been making a secret investigation into the air programme under authority of a letter from the President, came forward with a burst of sensationalism which swept away the last remnants of judgment on the aircraft situation. Detailed extracts from his report, charging every kind of inefficiency and criminality and bitterly assailing the patriotism of Colonel Deeds, were given to the New York *World* and published in two sections on March 21 and 22. The effect was electrical, removing all elements of doubt that something was seriously wrong.

On March 26 the uproar shifted to the floor of the Senate. Senator New stated that instead of 12,000 there would be but 37 American-built battle planes in France by July 1. Senator Poindexter bitterly assailed the Aircraft Board for refusing to build any "battle planes" at all. Senator Hitchcock gave voice to the rumors of graft, corruption and sabotage. Senator Lodge said that the "heavy Liberty Motor" might be satisfactory for heavy planes, but that the "light" Liberty was unsuited for combat work. The next day followed another outburst, when some air-

plane-manufacturing pictures were rushed out by the Committee on Public Information with grossly exaggerated captions due to the lack of distinction in the writer's mind between training planes and battle planes. On March 28 Senator Overman brought in another sensational element with broad charges that spies had seriously delayed manufacture. On April 3 Alan R. Hawley, President of the Aero Club of America, wrote to President Wilson that the whole programme was on the point of collapse; on the next day the *World* published the first of two very damaging stories that over-refinement in design had caused enormous losses in time and money with the Liberty Motor; and on the 5th the Aeronautical Society held a vigorous public meeting of protest and condemnation.

The upheaval was now under way with all the speed and relentlessness of a newspaper trial and with everyone joining in. The Aero Club and the Aeronautical Society came to blows over the degree of failure, and an automobile manufacturer offered $10,000 to the Red Cross if anyone could prove that the Liberty Motor was originated by another automobile manufacturer. The *World* secured a damaging statement from W. A. Morgan, formerly Vice-President of the Curtiss Company, as to the unwisdom of giving up the single-seater fighter, while meanwhile the storm continued to beat about the Liberty Motor.

Next came the reports of the Senate Committee, the majority flatly contradicting the minority. Rushed through at great speed, the majority report, claiming a "substantial failure" of the programme and charging "procrastination and indecision," appeared in

time for the afternoon papers of April 10. The minority report, following closely on its heels in time for the next day's morning papers, called the record one "of which every American can be justly proud," and said of the Aircraft Board that "in face of unparalleled difficulties it is accomplishing an unparalleled task with characteristic American energy, capacity, patriotism, and enthusiasm." Those who had not been perplexed before were left utterly at sea by these two diametrically opposed official reports.

On April 24 President Wilson cut the Gordian knot with a brief statement reorganizing the whole aircraft administration so far as was then possible. John D. Ryan, President of the Anaconda Copper Company and widely known as one of America's captains of industry, was placed in charge of all aircraft production for the Army. A Division of Military Aeronautics for the training of aviators and the military use of airplanes was organized, headed by Major-General William L. Kenly, just back from France. General Squier, previously head of both these branches of the Service, was directed to devote his attention to the Signal Corps proper.

The sensations, however, were by no means over. On April 29 Gutzon Borglum demanded a criminal investigation, and on the following day a fiery debate broke out in the Senate. On May 1 the Aeronautical Society gave out its full report, bitterly condemning the former aviation authorities, and on May 2 a Senator charged that they had played a "gigantic confidence game upon the country in the creation of the Liberty Motor, so-called." Obviously the situation was not to quiet down with the reorganization. An

investigation was imperative; the only question was as to the kind. Congress was very anxious for its own, even over the President's protest that the Department of Justice could better handle it. On May 8 Attorney-General Gregory announced that the Department would begin its investigation at once, under the direction of his assistant, William L. Frierson, but this did not satisfy Congress, and Senator Chamberlain announced that an investigation by a subcommittee of his Committee would continue unaffected.

Then came the startling publication at the White House of sworn statements intimating that Gutzon Borglum had sought personal profit in the aircraft field. He was said to have named as an asset "his personal friendship with President Wilson, whom he stated he could do anything with." These affidavits, coming from the Military Intelligence Bureau and given out at the White House, created an enormous sensation, and were at once branded by Mr. Borglum as a "scurrilous frame-up." A hardly less startling announcement remained to be made. With the Senate still determined on its own inquiry, President Wilson called upon Charles Evans Hughes, former Justice of the Supreme Court of the United States, who as the Republican nominee had almost defeated him for the Presidency the previous fall, to coöperate with the Department of Justice in its investigation. Mr. Hughes promptly accepted and at once took over the work, enlarging its scope so as to cover not only questions of criminality, but questions of efficiency and judgment as well.

The final step was taken on May 21. On that date a Presidential order was issued invoking the full power

of the newly enacted Overman Act to reorganize the Air Service in a thorough manner. The Signal Corps proper, under which aviation had developed, was now entirely divorced from that work. Two new branches of the War Department were created, the Bureau of Aircraft Production and the Division of Military Aeronautics, handling, respectively, the equipment and the operations phases. At the same time Colonels S. D. Waldon, R. L. Montgomery and E. A. Deeds were temporarily relieved of their aviation duties and ordered to coöperate with Mr. Hughes in his investigation.

Of the men who had originally laid out and carried through the first year the enlarged American air programme, General Squier had been assigned to Signal Corps work only, Mr. Coffin had resigned on April 23 and been replaced by Mr. Ryan on the Aircraft Board, Colonels Deeds, Waldon and Montgomery had been assigned to the Hughes committee, and Colonel Bolling had been killed in France. Thus came to an end, practically a year after the receipt of the cable from the Premier of France on which the whole air project was based, the first administration which had carried the burden of its development from practically nothing to an organization nearly as large as the whole Army before the war. Bitterly criticized and almost undefended, they were made to give way to new and fresh men who were to carry on under a new organization the structure they had begun.

Some day history will weigh their work and say whether they did well or ill with the great responsibilities, the great powers, the great problems entrusted to them. Such a clear-cut decision is not for the present,

with all its lack of perspective and understanding. The best that can be done now is to attempt to face their problems as they faced them, in order that we may gain a fairer measure of judgment.

Even Mr. Hughes, after examining 280 witnesses and taking 17,000 pages of testimony, does not offer a final summation in his report submitted on October 25. Throughout he calls attention to indecision, delay, and conflict of judgment, discussing especially lack of knowledge and experience, defective organization, lack of information as to the equipment required for service planes, changes in design and equipment, and conditions in plants both as to lack of experience and shortage of trained mechanics. The gratifying feature of his report was the dispelling of all the hysterical rumors, which had found voice even in Congress, that the Service had been honeycombed with corruption and pro-Germanism. As a matter of fact, Mr. Hughes recommended the court-martial of Colonel Deeds for "acting as confidential adviser of his former business associate" and for issuing "a false and misleading statement with respect to the progress of aircraft production," and criminal prosecution of three other officers under the statute prohibiting any officer or agent of the United States from transacting business with any concern in which he is financially interested. This finding, however, was trivial compared with what many persons had expected. Two of the three officers recommended for prosecution were shortly pardoned by President Wilson on the ground that their offenses were wholly technical and not in any sense serious. The evidence against Colonel Deeds was submitted to a special War Department

board of review, which after examining these and all other available facts recommended against his trial by court-martial on any of the grounds suggested. Secretary Baker announced his approval of this finding on January 16, 1919.

In attempting here a brief word picture of the aircraft development, it may be well to begin by calling attention to how immeasurably difficult it now is to recreate the atmosphere of those first days of the war. Everything at that time came hard and slow. Only the fringe of the country was interested in the struggle; universal service was first questioned and then haltingly adopted; the idea of sending a small expedition to France was put forward timorously; business leaders were giving only part time to the Government; industry was wholly unorganized; and Federal authority was still slim. The atmosphere of big things accomplished in a big, ruthless way which came with the second year of the war was entirely lacking, and progress was slow and halting.

The great outstanding fact is that the early hopes and promises stood unfulfilled at the end of the year. American aviation had not turned the scale in the Great War, although the question was still open as to whether it might not later. The optimism and enthusiasm of the year before, which had forced the adoption of such an unprecedented programme at such an unprecedented speed, now came back as a boomerang to sign the death warrant of those who had voiced it. What the story might have been had there been less optimistic publicity is a question.

First and foremost among the delays, overshadowing all others, was the utter lack of appreciation from

one end of the programme to the other of the difficulties involved. The incessant up-cropping of new needs, new shortages, new problems, the necessity of building up wholly new sciences, new industries, and scores of new training courses, constantly threw the date of realization further and further off. The men responsible for the programme were dealing with one of the most complex organisms in the history of human effort, handicapped by complete lack of experience, knowledge, and organization, and separated by 3,000 miles from the actual battle front. To none was the disappointment so keen as to those in charge. Always they had thought they were just on the verge of success when some new complication had entered in. By bitter experience only were they able to learn the intricacies that had through three years kept the Allied Air Services so small. Nevertheless, in all the flood of criticism they had the knowledge that a vast amount of work had been done, which, if not immediately manifest, could not fail to appear later in substantial results.

Other causes more human conspired towards these delays. The administrative personnel, for instance, was wholly inadequate. With new problems constantly breaking out before it was possible to provide the highly specialized men to meet them, the handful of men attempting to carry a burden always too heavy often delayed fundamental decisions to pass on immediate details. Moreover, the whole organization was new, growing, and restless. For most of the men the work seemed merely temporary; for many it was a stepping stone of ambition; for the draft-age officers, with their appellations of "slackers" and

"arm-chair officers" wearing spurs to keep their feet on their desks, it was distressing. Precious time was lost in making these human adjustments and more in moving to constantly larger quarters. Whereas originally the whole Service had been housed in four rooms, it moved from one building to another, some officers as many as six times, until eventually it had an enormous new temporary structure to itself.

Nevertheless, the foundations of an unparalleled development were laid in this first year. If the finished edifice did not rise in the time set, it was only because the preparatory work was far more difficult than the forecast. In a broad way, this first year developed an organization just reaching production in quantity in both personnel and equipment. In the latter it is not too much to say that a whole new industry had been built up. Whereas on the outbreak of war but one company had even approached quantity production of airplanes, there were at the end of the year over a score engaged on a very large scale, with another 15 on engines, and several hundred on auxiliary work.

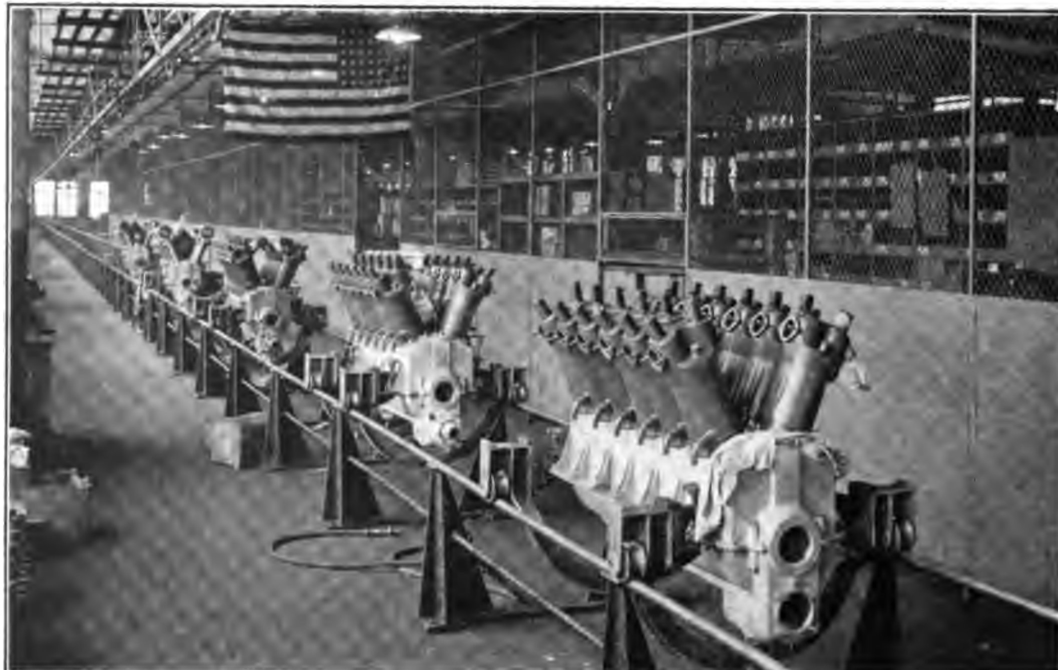
The tremendous problems of providing equipment to train the thousands of aviators and mechanics had been largely solved. Whereas before there had been only a handful of serviceable training planes, there were now more than were needed for the primary work, although planes were still short for the final training. A total of 4,437 primary planes with 6,394 engines, and of 1,168 advanced planes with 1,934 engines, had been delivered to May 23. This was sufficient to enable the training of aviators on a scale never before attempted, and it was one of the

solid foundation stones laid in this first year. Unfortunately, it has been almost wholly ignored.

In combat planes the situation was rapidly clearing. After innumerable delays in getting models and data from abroad, the De Haviland-4 battle plane had reached quantity production with shipments overseas begun in a promising way. The plane had been fairly satisfactory, with every hope that the "9" model would be wholly so. The Bristol, after a rather confused career, offered only dubious hope. In bombers the main difficulties had been overcome; both the Handley-Page and the Caproni had been redrawn for American manufacture and contracts let, and the first planes were due in a short time.

The Liberty Motor, much praised and much criticized, had solved the problem of quantity production of airplane motors and gave every promise of setting a good record on the other side. With only two companies in production to date, 1,110 engines had already been turned out, with the promise of 350 a week shortly. The Allied Governments had pinned their faith to the Liberty and had asked for all that could be spared. Other battle engines, the Bugatti 500-horse power and the Hispano 300-horse power, had long been in process of redesign.

The major problems of raw materials and accessories had been met. Half as much spruce was being turned out in one month as in all of the year preceding the war, largely by a practical domination by the Government of the whole Pacific Northwest lumber industry. A cotton substitute for linen had been developed and reached quantity production, this solving a problem that had troubled the Allies for



THE FIRST FIVE MACHINE-MADE LIBERTY MOTORS AT THE PLANT OF THE PACKARD MOTOR CAR COMPANY

three years. The shortage of dope had been met by drastic measures; 100,000 acres of castor beans had been planted to make castor oil; the Liberty Aero Oil had been developed as a standardized, economical and effective lubricant; and all the equipment, instruments, armament, radio and photographic apparatus, and the like designed and put into production.

The personnel of the Air Service had increased from 65 officers and 1,100 men to 12,846 officers and 137,368 men, nearly as many as the whole Regular Army of a year before. Twenty-nine large flying fields had been built whereas before the war there were but two, and nearly a score of other large projects, such as repair depots, concentration camps, storage depots, and the like, completed, all involving an expenditure of about $72,000,000. The country, indeed, was dotted with a system of great flying centers put up in the quickest possible time and bidding fair to have a very permanent effect on America's future in aviation.

For fliers 38,777 men had been examined by 71 medical boards established all over the country, and 18,004 accepted. Of these, 16,622 had gone to the ground schools for their preliminary work. Of the 10,592 graduates who had then gone to the primary flying schools, 4,094 had in turn been graduated into the advanced training courses. By contrast it is well to remember that a year before there had been 85 men in training in the United States for aviation. At the end of the year 3,997 men were in primary training, with a total of 21,940,000 miles flown to date. Beyond this a complicated system of advanced flying schools had been established for specialized

training. At the end of the year there were in these schools 266 observers, 138 army-corps pilots, 185 bombers, and 193 pursuit pilots, all getting the detailed training in the phases for which they seemed best qualified before taking their finishing training in France.

The three main lines besides flying needed for military aviation, namely, radio-telegraphy, photography, and machine gunnery, had been standardized through the fliers' course, so that each step followed its predecessor in logical sequence. For this work a very large instructional and operating force, of both officers and men, had been built up and established in photographic "huts," radio schools, or special aerial-gunnery schools wherever such training was being given. A host of other officers likewise had been trained, all for specialized work found vital to the Air Service in European experience. These included 852 supply officers, 718 adjutants, 448 engineer officers, armament officers and men, 52 compass officers, and 25 navigation officers. Each of these Services required a different type of school and a different type of student.

Of the enlisted men, over 10,000 had been put through special training to fit them for the delicate work about airplanes, engines, magnetos, carburetors, and the like. This alone had necessitated first a score of small schools scattered about in various factories, then a series of schools in the Northern flying fields, and finally four large schools in institutions already giving mechanical instruction. The graduates formed centers of larger instruction and promised to give the technical, practical knowledge

essential to keeping such an intricate mechanism as that of the Air Service in good condition.

Out of all this effort a constantly mounting stream was beginning to pour overseas. A force of 38,889 enlisted men had been sent across to build the airdromes, training fields and production centers for which Allied labor was short, and to prepare the way for the great aerial force to come. Over 2,500 men were in training as fliers in England, France and Italy, of whom 287 had finished their courses and gone to the zone of advance. The first two German planes were brought down by American Army fliers on April 14, just a year after our entry into the war, and the first American-built battle planes arrived at the front a month later. No one could doubt that the pressure, if late, had begun on a crushing scale.

Thus America stood at the end of the first year of the enlarged aerial programme, equipped with an Air Service nearly the size of the original American Army, with a great organization of fields, schools, and factories in this country, with all the primary-equipment needs supplied and the service equipment on the verge of production, and with the foundation of a great air force in France, men, schools, shops, and planes. Steep and arduous as had been the climb uphill, the personnel of the Service, the thoroughness of its preparation, and the magnitude of the industrial mechanism promised well as the curtain fell at the end of the first year and of the first administration.

Even yet the difficulty and complexity of the work was not generally realized. The amazingly small results in actual battle planes over the lines even

under the best conditions seemed wholly disproportionate to the vast effort and expense, for only a handful of people had yet seen that the finished airman is the tiny apex of an enormous pyramid. Nevertheless, America was slowly, if tragically, adjusting itself to a clearer and a fairer perspective of the long, arduous road to that newest and most romantic phase of warfare.

CHAPTER XIII

THE REAL MEANING OF THE PROGRAMME

Early problems of the new administration — The overseas programme — America's aims in aviation — Basis and method of the Allies' demands — The A. E. F. Aviation Project or Official Aviation Programme — The Air Service conceived as a great international striking force — Gradual expansion of the A. E. F. Project — Its disproportion both to the rest of the military programme and to British and French ratios — Comparison with the total Allied and enemy aerial force at the beginning of the July offensive of 1918 — Development of the Air Service continued by the new administration along the original lines — The final steps in reorganization: John D. Ryan appointed an Assistant Secretary of War — The development along individual lines during the final months of the war — The Liberty Motor in service and in production — The Hispano-Suiza and Bugatti motors — The plane problem still unsettled — The S.E.-5, a single-seater fighter, adopted — Night bombers — The Handley-Page and the Caproni — Observation planes and other bombers: a new Bristol, the Le Père, Loening, Pomilio, and Martin — The De Haviland battle plane in service and in production — Raw materials: spruce, wing fabric, and dope — Equipment and accessories — The situation at the termination of hostilities — The business problems involved — Capitalization and financing of airplane and engine companies — The cost-plus arrangement — Effect of the effort on American industry — Expenditures of the Air Service.

The reorganized Service was confronted at the outset with a condition of chaos and stagnation at Washington arising out of the upheaval in administration and the uncertainty as to the future. For some time the detailed administration had largely to drift on under its previous momentum while the new lines of major policy were being laid down. Fortunately there were good men at the fields and in the factories who

did not hesitate to assume responsibility during the confusion of readjustment, so that although new impetus from Washington was lacking for a time, development continued locally in both training and production.

The most vital problem to be definitely settled was that of the overseas programme to be filled. General Kenly at once cabled the American Expeditionary Force and received from General Pershing on May 20, 1918, a very detailed reply summarized in the statement: "Developments to date do not indicate the necessity for any change in my general organization and service of the rear projects approved here July 11 and September 18, 1917, respectively."

It is fitting here to digress for a moment to try to obtain a long-range perspective of what America aimed to do in aviation on the front. This is peculiarly difficult because of all the crosslights and shadows that tend to deflect one's vision from the straight line. Nevertheless, it is eminently worth while as illuminating a phase of America's war effort entirely distinct from all others.

More and more it becomes evident that the Allies, confronted on America's entering the war with her almost unlimited industrial resources and her complete unpreparedness, both intellectual and physical, to use these resources, were in a grave dilemma as to how best to lead her to the battle front. Unquestionably, in the delicate state of public opinion in this country, when the mere declaration of war itself without any thought of active military participation was considerable of a shock, it would have been fatal psychology for the Allies to demand of the United

States at the outset a large force of ground troops, especially as there was in this country neither adequate army for the purpose nor conviction to use it even if it were available. Consequently, America was led on step by step as her response seemed to justify and as the military situation of the Allies, at first favorable, became more and more difficult.

Of all phases of military activity calculated to appeal to American imagination, aviation stood out incomparable. Not only was this country proud in its parentage of the science of flying through the work of Langley and the Wrights, but it had felt a constant thrill at the gallant work done, largely to its own credit, by those fearless men who revived the name of one of America's founders in the Lafayette Escadrille. Aviation was a typically American field, far more appealing and stimulating than the other phases of warfare, which Americans still regarded as mechanical and professional.

Hence, as already described, Premier Ribot of France on May 26, 1917, seven weeks after the outbreak of war, sent the brief 150-word cable calling for 5,000 pilots and 50,000 mechanics, with 2,000 planes and 4,000 engines monthly beginning in January, 1918. The rapid amplification of this cable into the $640,000,000 programme and its passage, unsupported by the General Staff, through Congress on a wave of popular enthusiasm are a fitting testimonial to the shrewdness of the Allies' judgment.

Meanwhile, as all this work of elaboration was being carried out by the aviation authorities here, a similar work was being done by other Americans overseas. The first aerial programme to be received

here by cable from the American authorities abroad came on July 11, a week only, it is significant to note, after the $640,000,000 bill had first been presented to a Congress whose action on such an unparalleled demand could not possibly be forecast, and nearly two weeks before the bill actually became law. This evidences, of course, the simultaneous action of two groups of American aviation authorities, one here and one in France, and shows how clear the need appeared to both at the moment.

This July 11 programme, amended two months later by cable of September 18, 1917, laid down, as it was, almost in the first hours of the war, became known both as the A. E. F. Aviation Project and the Official Aviation Programme. All preparations, both here and abroad, were based upon it, and the country's resources were pledged to its fulfillment, despite the fact that it was somewhat of a private project, not specifically approved or disapproved by the General Staff of the Army, but allowed to continue on the basis that as much of it could be carried out as would not disrupt the preparations of the general military establishment.

The capital point of this programme was that it was immensely disproportionate both to any military force that the United States ever expected to put into France and to any ratio between airplanes and ground troops ever achieved by any belligerent power. It provided, in short, for an aerial arm beyond the most extreme needs of any expected American army and beyond any force that Allies or enemies had been able to build — and this in view of no scientific knowledge, experience, or plant in this country upon

which to build, in view of nothing indeed but raw materials and imagination.

America had been asked and had agreed to maintain 4,500 planes on the front, as against a total of but 1,700 French planes then actually in the zone of advance after three years of war. A total of 260 service squadrons[1] (120 pursuit, 80 observation, and 60 bombing), exclusive of 36 training and 90 replacement squadrons, were called for by June 30, 1919, which, with all the service of the rear, it was estimated in September, 1917, would require a force of 125,837 Air Service men in France. This, it must be remembered, was in the days when America was talking of sending only a small ground army overseas, primarily to carry the American flag to the front, heighten Allied morale, and have a general "moral effect" on the enemy.

As a matter of fact, this American air force was originally conceived as an American military con-

[1] The composition and personnel of the several types of service squadrons was as follows:

Monoplace pursuit squadron: 31 officers, including 25 fliers, 181 enlisted men.

Biplace pursuit squadron: 55 officers, including 50 fliers, 181 enlisted men.

Observation squadron: 43 officers, including 38 fliers, 186 enlisted men.

Day-bombing squadron: 49 officers, including 44 fliers, 181 enlisted men.

Night-bombing squadron, single-engined planes: 49 officers, including 44 fliers, 181 enlisted men.

Night-bombing squadron, multi-engined planes: 27 officers, including 22 fliers, 216 enlisted men.

Requirements of planes and engines for replacements were, in general, as follows:

Planes operating in daylight: 16 machines per squadron per month.

Planes operating at night: Five machines and seven engines per squadron per month.

tribution entirely distinct from any other military effort that might be made. Pilots could be trained in this country and all the maze of industries brought to bear to turn out over here material that for the space required to ship it would have supreme military value. Obviously a thousand fliers would far outvalue a thousand infantry, and their equipment would require relatively small cargo space. Consequently the contemplated American Air Service began to be spoken of as a great international striking force, destined to turn the scale wherever it might be sent, and with only a portion, often set at one-quarter, used with specific American troops.

The execution of this original programme, however, increased in difficulty and the programme itself in size with each elucidation of it made possible by fresh information from overseas. For instance, Secret Document Number 2 of April 8, 1918, estimated the total strength needed in France by June 30, 1919, at 153,054 officers and men, as against the September, 1917, A. E. F. estimate of 125,837. The total flying personnel, exclusive of replacements, it set at 11,606, whereas an A. E. F. letter of June 7 following set it at 16,550 pilots and 13,314 observers, and a Control Board analysis of June 4, figuring wastage at 40 per cent. for pursuit pilots, 20 per cent. for observers and day bombers, and 10 per cent. for night bombers, reached a total of 34,572 fliers.

Even at that time, even after the enormous increase over anticipation of the American ground army, this air force remained disproportionate both to our own vast military programme and to the British and French ratios. The A. E. F. programme provided

672 planes per 100,000 rifles, as against the actual numbers in operation in May, 1918, of 374 with the French and 294 with the British. On the French basis America's aerial programme would have been sufficient for an army of 6,000,000 men, and on the British basis, of 7,000,000. Indeed, the American programme would have provided by June 30, 1919, as many planes on the front as all the Allies together had on July 30, 1918, and nearly double the combined airplane equipment of the German and Austrian forces.

Just at this point it is well to examine the figures carefully in order finally to explode the prevalent exaggeration as to total airplanes in use, an exaggeration which so seriously led astray both officials and public in this country. On July 30, 1918, at the inauguration of the Allied offensive which resulted in victory, the total Allied aerial force in service from the North Sea to the Adriatic was 5,528 planes and 164 balloons. At the same time the total German and Austrian strength was 3,309 planes and 194 balloons. The contrast between these figures of August 1, 1918, with unofficial publicity campaigns in the United States only a year before for "a fleet of 100,000 airplanes" shows strikingly how preposterously misinformed this country was. That no official attempt was made until early in 1918 to throw the various Air Services into true perspective is an indication of official lack of vision as to the difficulty of the task undertaken; it was an omission which cost dearly when popular opinion rose in criticism. The contrast is all the sharper because a year before the belligerent services had been very much smaller, the

French, for instance, having increased 40 per cent. within the year.

To go into detail, the French Air Service, the largest of all, had but 2,820 active planes on the front on July 30, 1918, including 1,440 observation, 945 pursuit, 225 day-bombing, and 210 night-bombing. The British had a total of 1,664 active planes, with but 390 observation, 911 pursuit, 194 day-bombing, and 169 night-bombing. Italy stood next among the Allies with 614, including 277 observation, 282 pursuit, eight day-bombing, and 47 night-bombing. The United States, which was just beginning to appear on the front, had 270, with 126 each observation and pursuit, and 18 day-bombing. Belgium had 160 planes, including 105 observation, 45 pursuit, and 10 night-bombing. On the enemy side, Germany was credited by the French with 2,592 planes, including 1,290 observation, 1,080 pursuit, no day-bombing, and 222 night-bombing, while Austria was credited by Italy with 717 active planes, including 200 observation, 450 pursuit, no day-bombing, and 67 night-bombing. These figures, of course, take into account only active service planes, and do not consider service planes out of commission, replacements, or training planes; nor do they show the number of pilots, as most of these types carry more than one flier and all require replacement three or more times a year.

Despite the unparalleled expansion of the object sought to be attained, preparations had been made in the first year of the programme on a scale fully commensurate with it. These preparations had indeed fallen very far short of fulfillment, but they stood nevertheless as an outline of what had to be

done and provided a basis both of training and production facilities. The reorganized Air Service had, therefore, to meet the question whether to continue in the pathway laid out by the original administration in this first year or to strike out along radically new lines. The bitter critics of what had been done to date urged that the slate be wiped entirely clean and a wholly fresh start made. In the general chaos of misunderstanding which prevailed, anything was urged so long as it was different.

Nothing of the kind, however, was done. Aircraft development was continued along exactly the same lines as those on which it had started. Both in production and in operations the essential soundness of the original foundations was recognized. Weak places were bolstered up, rough edges smoothed off, various necessary additions put on, and the whole great mechanism, which had assembled almost by the spontaneity of its individual elements, was adjusted into a more smoothly running machine. Indeed, perfecting of the existing machinery rather than the institution of a new one was the end sought by the new administration.

At the very start, however, a great difficulty was encountered in organization. The upheaval in the higher administration which had taken the Air Service out of the Signal Corps had not set up a new and unified service, but had created two mutually independent bureaus, Aircraft Production and Military Aeronautics. This necessitated the separation of various functions that previously had been joint, such as administration of finances, control of supply depots and warehouses, and other business details. But

more serious than that, it created an unnatural obstacle both to the selection of types of planes having the best balance of military value with ease of manufacture and to the proper coördination of the production and the personnel elements of the Service.

After only three months this weakness was recognized in the final major step in reorganization, when on August 27 Mr. Ryan was appointed Second Assistant Secretary of War and Director of Air Service, responsible for both production and personnel. This at once gave the Service a prestige above that of any other branch of the military establishment, and marked a long advance from the time when aviation was but a section of a branch in itself very modest. It was a step also towards meeting the strong popular and Congressional demand for an Air Service entirely separate from the War and Navy Departments, for which justification was found in the experiences of the independent British and French Air Ministries.

Had the war lasted longer, this change would have been very important. As it was, however, Mr. Ryan left almost immediately for France, arriving on September 8 and leaving for home on the 30th, and his war term was too short for big results to work themselves out. As he himself said in his letter of resignation, ten days after the armistice was signed: "I have not taken over the actual direction of Military Aeronautics and my connection with it has not made any real change in its operations."

To follow through the detailed lines of development of the programme, the actual achievements in production may first be discussed, as shortage of equipment had been throughout the war the limiting factor.

Mr. Ryan, after a careful survey of the situation when he first took office, determined to continue on the existing lines, though on a much amplified and better coördinated scale. The Liberty Motor, the climax of the first year's industrial effort, on which America's aviation-engine industry had been concentrated and the Allied programmes largely based, was endorsed to the limit. No further proof is needed than that, whereas there had been but 22,500 on order in May, and those of the 12-cylinder type only, on November 11 there was on order 44,100 of that type and 8,000 of the eight-cylinder type, or more than double.

The motor had early made good in actual service. In July Vice-Admiral Sims cabled that a test of a Liberty-Motored seaplane gave "better climbing and load carrying" than similar planes with one of the best English motors. British officials endorsed it unreservedly, the Air Ministry on September 26 cabling: "Information officially expressed four months ago to effect that engine would prove satisfactory in service fully confirmed." On August 28 Mr. Ryan said:

> Everyone of our allies is calling for Liberty engines, demanding them, finding it impossible to meet their own production of planes with engines for them. They are all relying on our production of Liberty engines, not for a few engines but for a large part of their programme. They all now have Liberty engines and have tested them and tried them out. Particularly the English say to us: "We saw it first. We knew it was a good engine before you admitted it was." And they are satisfied with it and demanding numbers that are out of the question for us to meet — that is, they will take more engines than we can make. Remember this, that there has never been on either

side of this war a sufficient number of engines. That is the limiting factor in any air programme on both sides of the war.

Perhaps the final judgment on the Liberty Motor may be left to Mr. Hughes' report:

It now appears to be conclusively established that the Liberty engine is a great success for observation and bombing planes and that it has found high favor with the Allies. It is too heavy for the lighter pursuit planes . . . for which, indeed, the 12-cylinder type had not been designed.

Meanwhile, as the factories tooled up and began to swing into their full efficiency, the early delays in production ceased. Mr. Hughes says:

There is slight ground for criticism by reason of loss of time in perfecting the Liberty Motor. The difficulties were inherent in the task and the task itself was worth while. The weight of opinion is that it would have taken about as long to put any other high-power motor into successful quantity production in this country, according to our methods of manufacture, as it has taken to develop the Liberty Motor.

The production curve went steadily up. Whereas 620 Liberties had been delivered in the month of May, the figures rose to 1,102 in June, 1,589 in July, 2,297 in August, 2,367 in September, and 3,878 in October. By November 11, 13,574 had been turned out, 9,929 of the Army and 3,645 of the Navy type, with a daily production rate of around 150. Of the Army type, 2,474 had been shipped overseas, 1,464 were at ports or in transit, 4,777 had been delivered to manufacturers to install in planes, and 981 had gone to the British, six to the French, three to the Italians, 174

to the flying fields here, and 50 to the Navy. Of the Navy type, 2,432 had been delivered to Naval Aviation, 26 had been floated or were awaiting shipment, and 147 had gone to manufacturers, 31 to the French, two to the British, two to the Italian, and five to American flying fields.

Furthermore, the Hispano-Suiza engine, which had been started to production early in the original programme but not vigorously pushed, was greatly stimulated. The 180-horse power type was authorized to a total of 4,000, of which, by November 11, 469 had been delivered with 245 shipped overseas, and a constantly accelerating rate of production had been reached. The 300-horse power type was authorized to the number of 10,000, and although only eight were delivered to November 11, the hope of early and rapid production was good. The Bugatti engine, with 2,000 on order, was perfected in time to send overseas in the week before the armistice the first four motors of the eight produced.

At the termination of hostilities there were 68,100 service engines and 20,892 training engines on order in this country, a total of 88,992. A total of 14,059 service and 15,789 training engines had been delivered, a final total for the war of 29,848. These figures bear study. Only 18 months before the aviation-engine industry had been practically non-existent. During that time the Liberty Motor had been developed as the premier quantity-production heavy engine in the Allied programme; the Hispano-Suiza in four types, the Gnome and the Le Rhone rotary engines, and the Bugatti cannon motor had been adapted from foreign models; and the training-engine problem had ceased

to be. In fact, the complex aviation-engine problem stood solved.

The problem of planes, however, which was regarded abroad as far simpler, was still unsettled. The cancellation in November, 1917, of the original contract for 3,000 single-seater Spads had left the Government without a single-seater pursuit plane. As time wore on, the early overseas statements that the single-seater was to be replaced by the two-seater fighter proved more and more incorrect, as was strikingly shown by the fact that the final overseas programme of August 24 called for 60 single-seater squadrons out of a total of 202. During April and May the A. E. F. expressed increasing solicitude for a supply of single-seaters, and as a result a contract was given to the Curtiss Company for 1,000 of the S.E.-5 plane, a British plane which could be produced most easily here; it was just coming through when the armistice was signed.

Meanwhile, the planes of the other extreme, the heavy night bombers, Handley-Page and Caproni, were under development. The former, driven through under the stimulus of the tremendous Anglo-American night-bombardment agreement (described in Chapter XVI) and by the presence of a dozen British engineers, first took the air at the Standard factory at Elizabeth, New Jersey, on July 5. Christened the "Langley" in honor of America's pioneer aviator, with Lord William Semphill of the British Air Service as the driver, Major-General Kenly, chief of the American Service as a passenger, and Assistant Secretaries of War Crowell and Ryan among the spectators, the 9,000-pound monster with

its twin Liberty Motors and its 100-feet wing spread, carrying on its nose the Stars and Stripes and the Union Jack, performed in splendid fashion to the exhilaration of a crowd of 5,000 people. It was credited unofficially with a ceiling of 14,000 feet, a speed of 97 miles an hour, and a radius of flight of 600 miles.

Mr. Ryan took this occasion of success to make some generous remarks about the original aircraft administrators. As quoted in the *New York Times,* he said:

> There has been great dissatisfaction expressed by the people of the country at the results obtained up to the present in the production of aircraft. Some of it has been warranted — most of it has been caused by expectations beyond the possibility of performance. Much good work has been done by my predecessors and I am taking this opportunity to assure the people of the country that, in my opinion, there has been no such delay with the work or anything like such incapacity of those in charge as has been indicated in some of the criticisms of the accomplishments, or lack of them, in production.

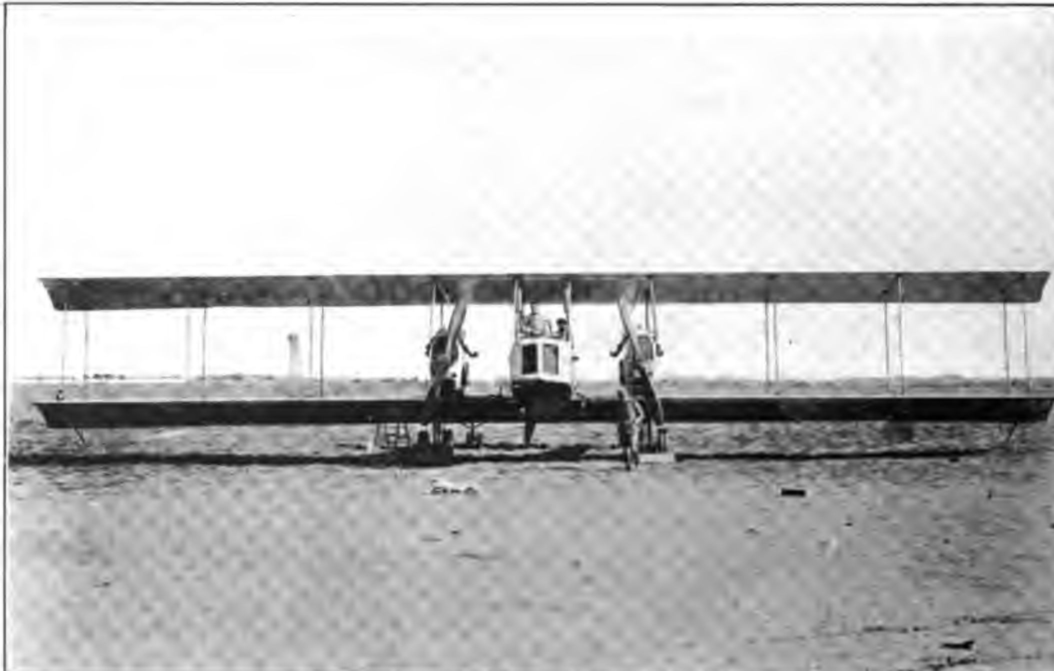
Production of Handley-Page parts began soon after the test. The first 10 sets were shipped overseas on July 25 to be assembled in British shops, tested in American-built fields and airdromes, and manned by American aviators. Up to November 11, 101 boxes of parts about 85 per cent. complete had been shipped to England, where their rapid assemblage and operation was assured.

The Caproni plane with its three Liberty Motors had its first test on July 4 at Mineola, Long Island, before an equally notable assembly. Although it gave fairly good satisfaction, there was a continuance

of the early delay between the Italian engineers who designed it and the American officials, so that at the termination of hostilities it was still awaiting its final official test at Dayton. The schedules called for its production to begin in March, 1919.

Progress was being made meanwhile in two-seater observation and other bombing planes. One of the early acts of the new Air Service administration was definitely to abandon the ill-fated Liberty Bristol, which in attempts to adapt a light body about the heavy Liberty Motor had cost the lives of four aviators, tied up the facilities of one of the largest factories, and caused a money loss of several million dollars. As announced on July 27, the plane was "overpowered and not of military value, lacking manœuvrability and not having sufficient speed for war purposes." However, another British Bristol was brought across which performed splendidly with a Hispano-Suiza motor, so that 2,500 of this type were authorized, and hopes were entertained that a good two-seater fighter would soon be available.

Coincident with this admitted failure was the promising development work of Captain Le Père, who had been brought over from France to design a special two-seater plane about the Liberty Motor. Of three types flown, one was credited by the Technical Section with the high speed of 132 miles an hour at 6,000 feet and 127 at 10,000 feet, a ceiling of 20,000 feet, and unusual climbing and manœuvring ability. Two of the first planes built arrived overseas in October for examination by the A. E. F., with the idea, if they were approved, of going into heavy production of the 3,500 authorized.



THE FIRST AMERICAN-BUILT CAPRONI BOMBER, EQUIPPED WITH THREE LIBERTY MOTORS, FIRST FLOWN AT MINEOLA, LONG ISLAND, JULY 4, 1918

Another most promising plane was the two-seater monoplane developed by Grover C. Loening, one of America's few aeronautical engineers at the outbreak of the war. In tests just after the armistice was signed it was credited with a speed of 145 miles an hour with full military load, including four guns, which made it faster than any European single-seater combat plane, and established another record by climbing 25,000 feet in remarkable time with two passengers. Much smaller than the De Haviland-4, it weighed but 2,400 pounds loaded for the air, practically the same as a single-seater scout, was driven by a 300-horse power Hispano-Suiza motor, carried fuel for three and a half hours, and gave a range of vision half as large again as any other plane developed.

At the same time the Pomilio brothers, who had been brought here with about 30 designers and workmen from great success in Italy, were progressing favorably at Indianapolis with both a single-seater with an eight-cylinder Liberty and a two-seater day bomber with a 12-cylinder, six of each of which were on order. At the termination of hostilities, also, the Martin bomber had been approved and 50 of this type had been ordered, and 10 Loening planes were under construction.

Thus, to a limited extent, the statement made by William C. Potter, Assistant Chief of Production, that there was not an aeronautical engineer in the United States in the spring of 1918 capable of building a plane fit for battle, was being overcome. With the aid of foreign experts, including Captain Le Père, the Pomilios, Captain d'Annunzio and his Caproni

experts, and a dozen Handley-Page designers, the experience gained by the Allies in three bitter years of struggle in this complex work was being disseminated throughout the American technical field.

There remains for discussion the De Haviland-4, the only American-built battle plane to see service on the front. About this plane beat a furore of criticism and doubt. After the original public outburst against the Air Service in April and May, a dangerous recurrence broke out in July when details of an A. E. F. cable requesting changes in the plane leaked out in exaggerated form. Finally the rumors became so alarming that Secretary Baker on July 31 said:

General Pershing has requested a large shipment of De Haviland planes of the present type on the priority schedule for August. The purpose of this is to set at rest the statement which was made from some quarter that no more De Haviland planes would be shipped, because he has asked for a very large shipment of De Havilands of the present type.

Then on August 17 came the cable:

First complete squadron American De Haviland-4 planes with Liberty Motors crossed the German lines on independent reconnaissance mission August 7. All planes returned safely.

This, the first flight of American-built planes over the front, aroused great enthusiasm in Washington, and the message was shortly made public by Secretary Baker in order to quiet the false reports.

Two months later Mr. Ryan returned from the front, where he had seen the American Air Service in action at St. Mihiel and in the Argonne. In a statement of October 16 he said:

The United States De Haviland planes were in general use for observation and day bombing in both the St. Mihiel and the Argonne attacks and the pilots were to a man enthusiastic as to their performance, and while individual pilots and commanders had suggestions as to improvements and betterments that might be made, they were individual and seldom indicated anything more than a personal preference for some rearrangement of details. The commanders of all the squadrons using De Haviland planes as well as planes of British and French manufacture for like purposes, told me that the pilots in every case would prefer to take a De Haviland machine with a Liberty engine over the line rather than any machine of a like type. This is due to the fact that the machine is fast and for one of its type is quite maneuverable; that it climbs well and the pilots all agreed is a very efficient machine for the uses for which it is intended.

The official figures on the De Haviland are interesting. It was credited in a Technical Section report with a ceiling of 19,500 feet, a ground speed of 124.7 miles an hour, a speed of 120 miles an hour at 6,500 feet, 117 miles at 10,000 feet, and 113 at 15,000 feet. Its endurance, which was much criticized at first, was given as two hours and 13 minutes with full throttle at 6,500 feet, and three hours and three minutes at half throttle.

Production had increased at a most gratifying rate. Up to November 11, of the 8,500 ordered, 3,431 planes, combining all the best and latest details in the complicated science of aviation, had been turned out by American factories, with a final week's record at the termination of hostilities of 260 machines. The total number actually shipped for the front stood at 2,000, with 644 for the final month of October, 496 at Hoboken awaiting shipment, and 112 *en route* to

the Atlantic seaboard when the armistice came to suspend hostilities.

Thus America stood in regard to planes at the signing of the armistice — a successful De Haviland observation and day bomber in quantity production and general use on the front; the Le Père two-seater fighter awaiting approval in France, and the Bristol with Hispano motor approved; the Pomilio, Loening, and Martin planes developing a new line; the Handley-Page night bomber in fair-sized production; the Caproni night bomber flying but not yet accepted; and the S.E.-5 single-seater just coming out. Whereas 19 months before the United States had possessed less than 300 very second-rate planes, it now had authorized 12,508 training and 29,854 service planes, with deliveries of over 3,500 service planes and 7,820 training planes. For actual battle service there were being turned out 150 Liberty Motors a day and 240 De Haviland planes a week.

Beyond the primary question of planes and engines, the maze of complicated equipment required completely baffles description. As already shown, the Government had gone into scores of collateral businesses to provide all the paraphernalia needed in order to assure the final plane assembler both of sufficient numbers and of the highest quality of material. Practically every phase of this work was in a virgin field, and practically every unit in it was vitally essential. All, therefore, had to come through into production in unison, despite the difficulties of design, manufacture, and changing types.

To start with the raw materials that the Government had to provide, the most spectacular, spruce

from the Northwest, had required logging operations unparalleled in history. The force of soldiers thrown into these primeval forests had increased to over 30,000 by the termination of hostilities, with logging railroads, donkey engines, mills, and all the other noise and bustle of lumbering breaking in on the vast silence to convert the forest patriarchs into the most romantic and beautiful of war's weapons. In mid-August the United States Spruce Production Corporation was formed by the Government, on the lines of the Emergency Fleet Corporation, in order to facilitate the business management of this great project and to allow the Allies, who previously had paid the same price for spruce as the United States, to bear their proportional share of the expenses of production. Up to November 11 the enormous total of 103,092,000 feet of spruce had been cut, of which there had been allotted 25,472,000 feet to the Air Service, 36,877,000 to England, 22,929,000 to France, 9,147,000 to Italy, and 8,667,000 to the Navy. In addition, a great amount of Douglas fir and Port Orford cedar had been cut, bringing the total lumber produced to 179,230,000 feet board measure, sufficient to meet American demands and provide 123,942,000 feet to relieve the Allies' serious shortage.

The cotton fabric that had been developed as a substitute to meet the world exhaustion of linen for airplane wings had proved so successful that it was used for both training and service planes, although originally the best hopes had been that it would be available only for the former. Up to November 11, 6,928,000 yards had been produced. At the same time, dope, the varnish-like substance used to stretch

and make the wing covering moisture-proof, had come into good production through the half-dozen plants financed by the Government; 484,000 gallons had been produced by November 11.

It would be almost hopeless to try to enumerate all the accessories necessary. For instance, 34,958 propellers had been delivered; 71,000 machine-guns of five different types, with nearly half shipped overseas; 11,000 synchronizing devices to allow firing through the propeller; 15,000 gun mounts; 86,000 gun sights; nearly 100,000 gun yokes; 114,000 bomb sights; 5,400 bomb releases; and 95,000 flares. Of 29 different kinds of instruments and other accessories, such as altimeters, speed indicators, clocks, compasses, fire extinguishers, inclometers, oxygen apparatus, safety belts, and the like, over 200,000 units had been delivered and appreciable shipments made overseas. Over 1,400 observation and enlarging cameras had been made, with much other photographic apparatus, and nearly a score of thousands of radio receiving and transmitting sets and other equipment. Of hangars, 1,424 steel and 2,500 canvas had been produced, and of balloons, 507, with much ferro-silicon, caustic soda, cable, cylinders, and winches. A large clothing organization also had been built up to equip airmen properly, as may be seen from a production, among other articles, of 52,000 goggles, 82,000 helmets, 23,000 sweaters, 33,000 hoods, 7,400 chin guards, 30,000 winter and summer flying suits, and moccasins, gauntlets, anti-sinking coats, face masks, knitted scarves, flying gloves, and mechanics' and construction men's outfits.

At the close of the war, then, production of the

hundreds of kinds of specialized equipment needed for the Air Service was under way in all its branches, and each little channel was beginning to carry its precious freight into the main stream towards a perfectly equipped fighting organization. Dates of delivery had been set back time and again by unexpected difficulties and some elements had reached production before others. Advanced-training equipment was still inadequate, and battle-plane and -engine production was still disproportioned because of lack of light fighting and scouting machines, but with every day that passed the unevennesses were being ironed out and a well balanced programme being approached.

The United States stood on November 11 as the Allies' certain hope in aviation, her Liberty and Hispano motors, her De Haviland and Handley-Page planes, her spruce and other raw materials and accessories tried and proved, with an inexhaustible storehouse behind them just opening to unparalleled strength.

The business problems involved in all this new development were complex in the extreme. First and most pressing after the lack of experienced companies, was the lack of capital in or available for the airplane industry. At the outbreak of war the total capitalization of all plane and engine companies combined did not pass $15,000,000, more than two-thirds of which was concentrated in two concerns. The total estimated for all specific plane companies was $6,419,000, of which the Curtiss Company alone claimed $5,400,000, while Thomas-Morse claimed $246,000; Standard, $220,000; Dayton-Wright, $122,-

000; and Fisher Body Corporation, nothing. Out of a total of $6,650,000 invested in airplane-engine work, Wright-Martin claimed $5,240,000; Packard and the General Vehicle Company, $500,000 each; and Hall-Scott, $290,000. Not over 6,000 men were engaged in airplane work and 2,000 in airplane engines.

Aviation up to that time had not commended itself to American business men, and there was no reason to expect that it would in the near future. Considerable money had been lost in projects that never passed the experimental stage, and an unenviable reputation had attached to the industry. Moreover, with every week of the war money became scarcer and capital more cautious, and it finally became evident that private financing had come to an end until the return of peace. Consequently, large loans were made by the Government to the companies who came forward in generous spirit with their plants and skilled labor to contribute their part towards winning the war in the air, despite the dubious future of the industry as a business venture after the war.

No experience was at hand for the establishment of a just price for aviation supplies. The complete lack of large-scale production up to that time, the informal methods of manufacture, and the absence of a steady market all contributed to a general uncertainty as to the actual cost of production and the consequent price to be charged the Government. Government auditors at once sent into the factories were convinced that even the companies themselves had no scientific knowledge of costs. There was no time, however, to haggle over terms. What was

needed was the immediate concentration of all thought and energy on the task of enlarging the factories, training labor, and getting into production, with the general understanding that a price would be paid that would be fair to both parties.

The cost-plus arrangement was accordingly adopted, with results which dispelled the immediate financial confusion and proved with experience to be generally satisfactory. A "bogie" price was set by agreement to cover the estimated actual cost of production. On this a fixed profit was allowed of 10 to 15 per cent. according to circumstances, with additional incentive to the manufacturer to reduce rather than pad his expenses, first by not allowing him a percentage on any costs above the "bogie," and second by allowing him to add to his profits a quarter of any savings effected under "bogie." This provided as adequate protection to both sides as was possible in the rush and confusion of a new industry. When experience showed the "bogie" to be high, as in most cases it did, a readjustment was made to correct it. This happened especially in the case of the Liberty Motor, which with increased skill in production was reduced in "bogie" nearly 50 per cent.

With the Government willing and able to advance the otherwise unavailable capital needed for the expansion of the industry and a fair price arrangement reached by means of the cost-plus agreements, American manufacturers threw themselves with all earnestness into the task of creating almost overnight a wholly new industry in a field complex beyond all anticipation. Factories were enormously enlarged, labor forces increased time and again, and the most

elaborate and expensive machinery bought, all with a single eye to quick production for the war.

This effort wrought a great change in American industry. A new business was established which at the termination of hostilities had acquired the ability to turn out within a year's time the billion dollars worth of equipment for which appropriations had been granted. Also a new skill and technique had been developed that allowed American factories to turn out in quantity and with a high standard of quality the delicate equipment which abroad could be made only by hand. As Secretary Baker said in his annual report: "The success achieved in securing quantity production is a gratifying commentary on the manufacturing ability of this country."

The amounts of money actually spent by the Government have been very generally misunderstood, sometimes because of confusion with the sums appropriated, and sometimes because of broad charges of corruption and inefficiency. These may best be met perhaps by reference to Mr. Hughes' report, which, while criticizing some of the original prices as perhaps high, and pointing to a certain waste in experiments and delay in selecting types, contains no evidence of actual misappropriation of funds. That such vast sums were handled with such haste and informality without any trace of corruption is cause for gratification.

The actual sums spent and the main headings under which they fall may be touched on briefly. Mr. Hughes found that up to June 30, 1918, the actual disbursements for airplanes and engines and spare parts of both (including payments for experimental and development work) were: under the $640,000,000

THE THOMAS-MORSE SCOUT (LEFT) AND THE LOENING MONOPLANE (RIGHT)

appropriation, $142,908,398.95; and under other appropriations, $12,627,547.46; making a total of $155,535,946.41. Of this amount $25,605,074.31 was expended for manufacture overseas; $21,491,551.14 for advances to contractors; and $1,697,830.19 for experimental and development work. These items amounted to $48,794,455.64, leaving the actual disbursements on account of production in the United States $106,741,490.77. Expenditures for purposes other than airplanes, engines, and their spare parts brought the total disbursements to June 30, 1918, to $430,234,316.99. The total disbursements under the $640,000,000 appropriation were $363,818,014.87, leaving in the Treasury of this appropriation an unexpended balance of $276,181,985.13 at the end of the fiscal year.

The Army Appropriation Act of July 9, 1918, continued the prior appropriations for the Air Service, and in three months ending September 30, 1918, further disbursements were made under the $640,000,000 appropriation of $128,265,038.31, and under prior 1918 appropriations of $7,250,915.36, a total of $135,515,953.67. The same Act made a new appropriation for the Air Service of $884,304,758 for the fiscal year ending June 30, 1919, and under this appropriation $3,670,707.66 was actually disbursed up to September 30, 1918.

Thus to within six weeks of the signing of the armistice the total disbursements of the Air Service, out of appropriations for the two fiscal years 1918 and 1919 aggregating $1,576,156,624.47, amounted to $569,420,978.32. Under the $640,000,000 appropriation $492,083,053.18 had been expended, leaving a balance of nearly 150 millions. This sum, of course,

was fully covered by obligations contracted for but not completed, as was much of the appropriation for the fiscal year 1919, but from the signing of the armistice these allotments were gradually reduced by cancellation of orders. By February 7, 1917, these cancellations amounted to $468,847,993.

The relative importance of the main classes of expenditure is shown in the following statement of the allotments under the $640,000,000 appropriation:

Airplanes and spare parts	$191,037,977.47
Engines and spare parts	190,736,194.05
Transportation (equipment)	42,966,110.47
General equipment	34,240,825.08
Maintenance (of supply depots, etc.)	14,250,982.89
Special clothing	2,508,960.26
Machine guns, ammunition and bombs	28,823,998.02
Acquisition of plants	2,595,853.38
Miscellaneous (supplies and expense)	6,172,754.46
Purchase and lease of land	707,199.87
Construction of flying fields, etc	57,205,544.10
Construction of buildings abroad	7,520,231.61
Balloons	10,210,930.83
Balloon buildings	110,793.76
Transportation (equipment), Balloon Division	1,003,040.60
Gas for balloons	3,411,954.49
Miscellaneous (equipment, supplies and expense), Balloon Division	1,812,619.98
Aeronautical schools, maintenance	1,074,054.89
Expenses, special duty, home and abroad	50,140.00
Pay of Reserve Corps and traveling expenses	14,055,139.16
Pay of civilian employees	3,604,571.40
Vocational training	238,085.73
Experimental investigation	2,948,601.83
Miscellaneous expense	134,377.67
Departments and depots (expense)	151,607.38
Foreign expenditure	26,600,000.00
Aircraft Board (expense)	47,240.00
Total	$644,219,789.38
Material purchased for resale	148,534,836.17
Total allotments	$792,754,625.55

CHAPTER XIV

THE WORK AT THE FIELDS

Development of training during the final half-year of war — Adequacy of facilities to meet the A. E. F. Aviation Project — The programme modified by delays in production — Difficulties of coördination between the A. E. F. and the Air Service — The personnel programme and the personnel at the termination of hostilities — Products of the training system — Ground schools — Primary training — Pursuit pilots — Aerial observers — Bombing pilots — Aerial-gunnery schools — Photographic, radio, and mechanical personnel — Casualties in training — Extent of the conquest of the air — A formation flight of 103 planes — A flight from the Gulf to the Great Lakes — A landing in the midst of the Everglades — Examples of aviators' troubles — A military transcontinental flight in formation — An altitude record of 29,000 feet — Parachute descents from airplanes — Fast flights — New uses for airplanes — Passenger carrying — The aerial mail service — Development of the aerial radio-telephone — Its use in formation flying and influence on aerial tactics.

All the great work of training, including flying, photographic, radio, and mechanical personnel, was both improved in quality and concentrated in location during the final six months of the war. The complex educational system which had developed so rapidly during the first year was amplified and harmonized as time, experience and equipment gave opportunity. As with production, however, the essential foundations laid in the first year remained unchanged.

The first problem, of course, was to ascertain whether the schools had sufficient capacity to meet the overseas programme. Hence, when General Pershing cabled on May 20, 1918, that the original programme for 260 service squadrons at the front by

June 30, 1919, still stood, a careful canvass of facilities by the Control Board was ordered. On June 4 the Board reported that 34,572 pilots and observers were necessary to meet the programme and provide replacements of 40 per cent. for pursuit pilots, 20 per cent. for observers and day bombers, and 10 per cent. for night bombers. Always provided that sufficient equipment were available, it was found that the existing training system was fully adequate.

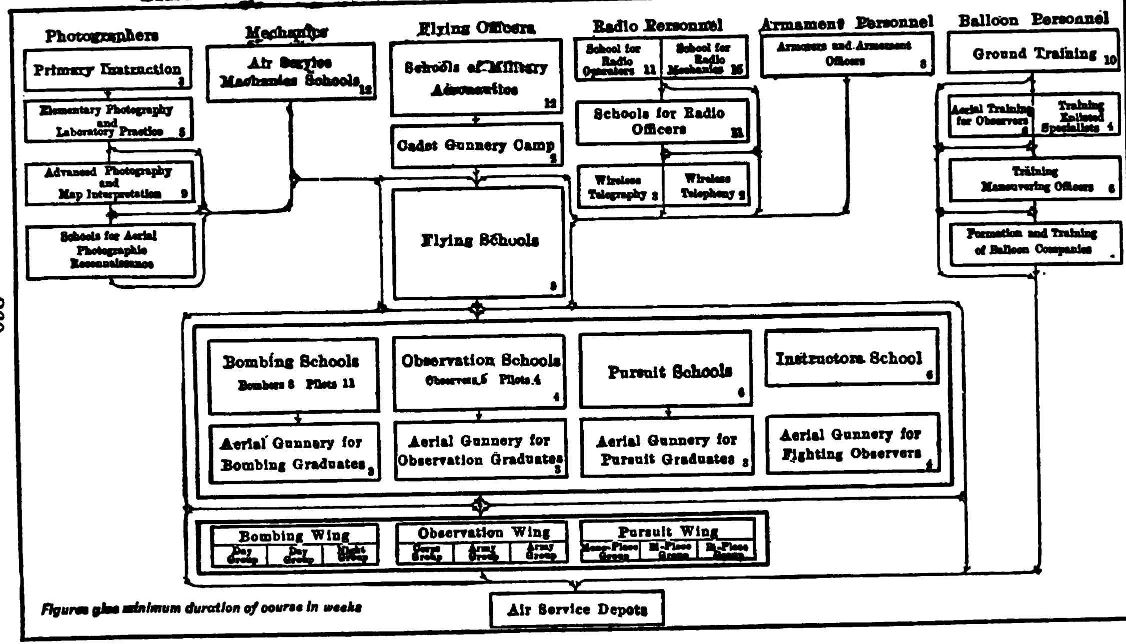
Meanwhile the Bureau of Aircraft Production had been estimating its capabilities to meet the programme, and on June 26 it reported that instead of 260 squadrons at the front by June 30, 1919, it could provide equipment for but 182 squadrons by September 30, 1919, three months later. This forecast of delay in production dictated a recasting of the training programme to prevent the formation of an unnecessarily large pool of fliers to the consequent demoralization of those who would have no chance of securing equipment for active service. Accordingly, as there were as many fliers in training as were needed to meet the production programme, three of the eight ground schools were closed, admissions to the others were limited to only 75 enlisted men a week, and the training programme was retarded in several other ways.

The authorities overseas, however, not fully aware of this situation, began to call in large numbers both for flying personnel to fill the advanced schools in France and for squadrons to develop the great service of supply necessary. They were acting on the assumption that during all this time a large reservoir of both

kinds of personnel had been built up here, whereas the General Staff had allowed only a very negligible enlargement because of production delays. On August 7, 1918, for instance, the American Expeditionary Force requested 40,100 Air Service men within the next few weeks, whom it was practically impossible to supply, and for whom, so far as was known here, no adequate equipment existed abroad. An immediate reply requested the A. E. F. to postpone its call as far as possible, and this was followed shortly by another dispatch detailing the production situation. As a result the original A. E. F. programme, laid down on July 11, 1917, and amplified on September 18, 1917, was modified for the first time. Instead of 260 squadrons, the A. E. F. in a cablegram of August 24 reduced the total called for by June 30, 1919, to 202 squadrons. Even at that the figure was above that set by the Bureau of Aircraft Production and accepted by the Division of Military Aeronautics in its reduction of programme, the difference being due to the force already in hand in France and the equipment available there.

As a matter of fact, the three parties to the Air Service programme, the A. E. F. overseas and Military Aeronautics and Aircraft Production here, were finding it very difficult to work absolutely in unison. The A. E. F. laid down the general programme to be filled, and Military Aeronautics and Aircraft Production each endeavored to carry out its part of it. Military Aeronautics, however, was dependent upon Aircraft Production for equipment to train its personnel, and as a result it found itself between two fires, the A. E. F. continually demanding more and

CHART OF AIR SERVICE TRAINING AND CHANNELS OF TRANSFER



more trained men, and Aircraft Production not able to provide enough of the complicated training equipment necessary.

The shipment schedule from overseas of May 20, 1918, for instance, called for approximately 56,000 men between that date and November 11. Subsequent special cables, based on the increasing needs of the situation overseas and sent in the belief that a large pool of men had been built up here, increased this number to 67,523 men. These figures, however, were beyond what the Air Service was able to supply, owing to the fact that because of shortage of equipment and the great need for men in other services, the higher War Department officials had not felt able to provide the new personnel in the large numbers and with the haste necessary.

On October 3 a final chart of the personnel needed to June 30, 1919, was submitted to the General Staff. This called for a grand total of 267,305 officers and men, including 162,200 overseas. Against this, the total strength of the Service at the termination of hostilities stood at 151,742 officers and men, of whom 78,399, or slightly more than half, had been embarked for overseas.

The actual training[1] all this time continued under

[1] The accompanying chart of Air Service training and channels of transfer is a simplified reproduction of a very detailed chart prepared in the office of the Chief of Training, Division of Military Aeronautics, revised to October 23, 1918. The original listed under each head the fields or schools engaged in the particular element of instruction or training, their locations, commanding officers, and capacities. A complete list of flying fields, schools, and other stations of the Air Service as of November 11, 1918, is given in Appendix II, and it is unnecessary to repeat these data here.

the reduced programme with increasing efficiency as equipment, experience, and the number of instructors increased. The development of military aviation ultimately required the establishment of a total of 40 flying schools, five schools of military aeronautics, eight balloon schools, three radio schools, three photographic schools, and 14 air depots. Up to the termination of hostilities a total of 22,542 men had been admitted to ground schools as the first step in their progress towards becoming aviators. Of these, 4,291 had been discharged and 16,857 graduated, including 1,791 sent overseas for flying training in the summer of 1917 and 14,835 sent on to American flying fields. Three ground schools, at Carnegie Institute of Technology, Cornell University, and the Ohio State University, had been ordered closed on August 4 as a result of the low estimates of production of the early summer, but Cornell was held open when new figures from overseas indicated another increase in programme, and at the end of the war it was preparing for the admission of 2,570 cadets monthly.

Primary flying training developed in a very satisfactory way, with 15 units in operation. To the termination of hostilities 8,688 men were graduated as reserve military aviators competent to execute all the ordinary elements of flying, including starts, landings, cross-country flights, and a few stunts. Although not trained in the acrobatics, formation flying, aerial gunnery, and other specialized work necessary before going over the front, these men had all the training necessary for peace-time flying as distinct from military flying. With men trained overseas, therefore, the total of men able to take a plane into

the air, fly it, and land it was well over 10,000, as against barely 100 so trained 19 months before. Of the 12,231 cadets who had actually begun this primary course, 377 had been discharged from further instruction, 204 had been killed, and 2,764 were still in training. A total of 652,009 hours had been flown, a truly stupendous figure in comparison with anything ever done before. Primary planes were sufficient in number, with 1,790 on hand on November 11, 976 of which were in commission. Each plane averaged 2.66 hours daily in the air, and each cadet 1.07 hours.

The specialized courses which followed this primary work and fitted the reserve military aviator to be a pursuit pilot, observer, or bomber over the enemy's lines all developed appreciably in the second year of the war, but not sufficiently to meet the large A. E. F. demands. This was due almost entirely to the continued shortage of the highly complicated equipment necessary, this forcing the adoption of improvised material, which in turn lowered both the speed and the quality of training. As a matter of fact, the United States was endeavoring to provide, both for the front and for home use, a mass of equipment never before produced here and not yet produced in any country in the world on a similar scale.

Of the specialized courses, pursuit training expanded from one single-unit field to four units during the last six months of the war. These fields were especially chosen in Florida and California to insure the best weather possible. In spite of there being only 384 single-seater planes to supply a need of 800, and those slow, weak in construction, and difficult to stunt, 479 cadets were graduated from this course to

November 11. On July 15 the A. E. F. had requested 125 pursuit aviators weekly, and this was being met at the termination of hostilities by sending 50 pursuit cadets and the balance of reserve military aviators capable of pursuit work.

Aerial observers, who in the spring of 1918 had been very limited in numbers, were also being graduated at accelerated speed. Whereas at the outset personnel for this work had been provided by the Field and the Coast Artillery, often including men who could have been spared without loss to the Air Service and others who were reluctant to leave their own services, during the summer the confusion thus created was dispelled by having all observers commissioned in the Air Service, which thus became solely responsible for them. This change was supported by experience overseas, which showed that the system of having pilots responsible to the Air Service and observers responsible to the line organization brought about a serious lack of coördination. As a result of the change observers' training was greatly enlarged, so that by the termination of hostilities 1,192 pilots and 907 observers had been graduated for this work, and 615 pilots and 509 observers embarked overseas.

Bombing training, wholly unknown in this country up to January, 1918, also developed appreciably, thanks to the ingenious improvisation by the men at the fields of many kinds of essential equipment. Bombs, bomb sights, release mechanisms, signals, wing flares, etc., never before made in this country and but slowly adopted as to types, were critically lacking at first, and consequently the training was slow, incomplete, and restricted in capacity. While

regular dummy bombs and release mechanisms were being made, improvised plaster of Paris bombs turned out at the fields were used despite their variable trajectories, and the roughest kinds of bomb release mechanisms were adopted. By the termination of hostilities these difficulties had been largely overcome; 414 bombing pilots and 329 bombing observers had been graduated, of whom the first had been used as instructors of those to follow, and a large number had been sent to France.

What made all kinds of specialized training most difficult was the lack of service planes such as the men would have to use at the front. Early in June, 1918, 25 per cent. of all service planes produced were requested for training purposes, but the needs at the front were so great that they could not be diverted. On August 7, however, the Chief of Staff granted a request to divert 10 per cent. of such planes, which should enable the Air Service to "send to France trained units, who can go immediately to the zone of advance, receive some 'refresher' flying on machines they already know, and start to work over the line." By the termination of hostilities a good beginning had been made along this line, with 170 De Haviland planes in use for training.

The aerial-gunnery schools, which supplied the final step in the training of fliers in this country, had developed proportionally. Whereas in the spring of 1918 but a few planes were equipped with machine guns for this work, the provision of 341 planes by the termination of hostilities enabled active schools to function at Ellington, Selfridge, Taliaferro, and Rockwell Fields, with a total of 2,295 graduates.

Special schools for flying instructors had also been instituted at Gerstner, Kelly, and Brooks Fields, with 732 officer and 10 civilian graduates.

Non-flying training was similarly improved as time wore on. In aerial photography, the large developers' and printers' school at Rochester, in the heart of the photographic industry, was in full swing, with 1,567 graduates to November 11. The advanced course at Cornell had been extended from six to nine weeks, courses on mosaics, stereos, plotting, and artillery camouflage added, and 258 officers and men graduated. A final school had been opened at Langley Field, at which men trained individually were organized into units ready for overseas duty and given actual field training in conjunction with the school of observers and by means of missions into the country round about lasting from two days to a week. A total of 32 photographic sections had been distributed among the "huts" at the various fields, many of them engaged in mapping aerial routes over wide stretches of territory.

Radio training, which had been entirely in charge of the Signal Corps at the time of the separation of the two services, had become very much more specialized. On June 30, 1918, the schools at Columbia University, Carnegie Institute of Technology, and the University of Texas were taken over, and very shortly a new course of three weeks was added at Ellington Field to give actual field instruction from dugouts in conjunction with airplanes. Moreover, the confusion which had existed as to the training of Field and Coast Artillery radio personnel was solved by having all this training done by the Air Service instead of,

as before, by these line organizations. As a result of the increased facilities provided for this work there were graduated to the termination of hostilities 240 radio officers, 369 operators, and 780 mechanics. In addition, a special course had been instituted by an officer brought back from the A. E. F. to train operators in reading land radio signals directing the navigation of night-bombing Handley-Page squadrons, in order to prevent a serious loss of planes by aviators' losing their way home.

Mechanics' training had been concentrated in two large schools at St. Paul and Kelly Field. The final step in the evolution from the 34 original schools scattered at various factories all over the country was taken in late June, when the three schools at Pratt Institute, Carnegie Institute, and David Ranken School were given up. The two final Government schools were very much enlarged, but lack of equipment and personnel prevented their reaching their full capacity either in quality of training or in numbers. At the termination of hostilities 7,661 mechanics had been graduated from the various courses, and 1,729 more were in attendance.

But to return to the flying fields! An amount of flying unprecedented in the history of the world was going on daily in the great network of 31 fields scattered over the United States. Whereas a total of 407,999 hours had been flown in the 12 months ending June 30, 1918, a total of 403,073 hours were flown in the period of less than four and one-half months between that date and the signing of the armistice. Figuring this at 80 miles an hour, American aviators in this country made over 32,-

000,000 miles of air travel in little over one-third of a year, and over 64,000,000 miles during the war period.

All this was not without its price. Many precious lives were lost in this preparation of the air army, as truly sacrificed for their country as though they had fallen over the lines in France. Up to November 11 a total of 278 men made the supreme sacrifice at flying fields on this side. In spite of all precautions, in spite of the most urgent regulations, fatalities proved unavoidable, some due to dangers inherent in the abnormal flying required for war work, some due to purely human weaknesses in the fliers. Averaging this number against the total of 811,072 hours flown gives one fatality for every 2,960 hours or 236,800 miles, a very much more favorable record than similar figures for Americans trained in France and England or by the Canadian authorities in Texas.

Among these sacrifices special mention will not be out of place of the tragic death at Gerstner Field of Major John Purroy Mitchel, former Mayor of New York and a man of the greatest promise. Major Mitchel, despite the fact that his age of 37 years seemed to bar him from aerial fighting, sought the most dangerous branch of the Service, single-seater pursuit work. On July 6, 1918, when at about 600 feet altitude, he fell headlong from his plane, which went skimming off for half a mile without a pilot, finally dashing to earth completely demolished. It was found that the strap to fasten the aviator in the plane had not been put in place.

To prevent accidents so far as was possible by

SQUADRON OF SIXTEEN PLANES IN BATTLE FORMATION, ROCKWELL FIELD, CALIFORNIA, JUNE, 1918

keeping fliers in sound physical condition, a special corps of flight surgeons and physical directors were early appointed. The former acted as specialists with broad powers to force men to rest; the latter built up a careful system of training through athletics, swimming pools, tennis courts, and physical exercises. In August, 1918, all fields were ordered to install ambulance airplanes, which were proved at Gerstner Field not only to be more gentle in their motion than an automobile ambulance, but also to be able to reach places inaccessible to motor cars.

The price paid by many aviators, however, helped to open the skies to their companions. With every week that passed the scope and power of flight was made to increase enormously. Whereas at the outbreak of the war the few fliers on hand had timorously circled about their fields, the aviators at the end of the war were able to soar off freely and safely wherever fancy called them. Cross-country flights in all that great section of the Southwest from the Pacific to the Mississippi, especially all about Texas, became matter of common occurrence. Places in the Southwest under the air lanes used by Army fliers vied with each other in hospitality to aviators. One town, calling itself "The Dynamo of Central Texas," sent out the following card to aviators:

Upon presentation of this card, all courtesies will be offered you, including shower and pool baths at the Y. M. C. A.'s $87,000 plant, Country Club's $75,000 plant, Elks Club $47,000 plant. Coffee and sandwiches will be handed out by the Red Cross Canteens; hair cut, shave and shine given free at any barber shop; cold drinks at the soda water fountain, also local carfare.

How complete the mastery of the air had become is shown in the following report of a monster flight in California:

One hundred and three airplanes from March Field, Riverside, California, made a flight of 160 miles in battle formation on October 12 without a single accident. This large squadron bombed Los Angeles with Liberty Loan literature.

This is believed to be a record never before equaled in any of the flying fields in the United States. It was not a special performance with a number of picked planes and pilots but was a wholesale turn-out of the school. The total mileage of this trip was over 16,000, which, without a fatality or the loss of a ship, made the performance a very remarkable one.

The gigantic formation taxied off, circled the course, assembled in 10 separate and distinct units and finally headed in one solid formation for Los Angeles, 60 miles distant. The 103 planes got into the air in six minutes, maintaining an approximate altitude of from 3,000 to 6,000 feet.

The Arcadia Balloon School was advised by wireless of the approaching squadron and two ships were sent out to escort the formation over the city. A realistic battle-front feature of the flight was accomplished when the air fleet passed over the balloon school, seven huge observation balloons having been in the air at the time.

While thousands of persons craned their necks to get a glimpse of this American air armada, the planes suddenly swept down from the mountain peaks, giving Los Angeles a realistic imitation of a real air raid. Bombs were dropped, and from them fell leaflets saying: "What if we were Germans? Buy Liberty Bonds."

Accompanying the air fleet was a hospital plane and a flight surgeon. All the planes were of the Curtiss JN-4D training type. Approximately 3,000 gallons of gasoline were consumed. The ships returned in formations of 10, several by more distant routes after visiting numerous

Southern California towns and cities in the interest of the Liberty Loan.

Previous to this the largest number of planes visiting an American city was 68, when members of the First Provisional Wing of the American Air Service flew over New York City. In the March Field squadron, half of the pilots participating were cadets, pilots in training, while the remaining pilots, other than unit leaders, were for the most part flying officers who have been commissioned at this field since July.

With but one exception, all of the planes to leave March Field returned on scheduled time, this feat in itself being a record. One was required to make a forced landing in the outskirts of Los Angeles when the motor "froze" in the air.

A good instance of the complete independence of the modern airman was afforded by a 4,000-mile zigzag flight made by Lieutenant John E. Davis from the Gulf of Mexico to the Great Lakes and back during October. Without changing plane or motor, without knowing the route or the landing places, without mechanic or landing lights for night work, he covered the distance from Ellington Field to Mount Clemens, Michigan, and back in 64 flying hours over a period of nine days. His experience with a heavy storm over the Mississippi River, alone among the elements, is described in his log as follows:

I climbed to 5,000 feet and flew over the storm for two hours. At the end of this time I figured I was nearing Little Rock and descended into the storm clouds to check my course. I no sooner entered the clouds at 4,500 feet than my compass started acting peculiarly. My ship was buffeted around and I completely lost control. I cut my gun and watched my altimeter and noted that I was falling at a high rate of speed. My controls were absolutely useless, so I left them alone, awaiting in readiness to right

myself upon emerging from the clouds. I finally came through the clouds in a steep nose dive and side-slip at an altitude of 300 feet. I righted myself and looked for a landing place, because I feared that the rain would stop my motor. Was unable to find any place to land, the country being covered with forest. I flew along at 300 feet for some time and found that I had covered only half of the distance I should have by this time. I climbed carefully through the clouds to 5,000 feet and passed the storm in about one and one-half hours.

To a much more surprising predicament was brought Lieutenant Smith, who set out to map a shorter flight from Carlstrom Field (Arcadia, Florida) over the Everglades to Fort Myers. He had reached an altitude of 7,000 feet above the great swamp when he observed a storm approaching from the south and changed his course to get around it. Finding this impossible, he veered to the west and attempted to climb above it. At 8,000 feet, however, he encountered a terrific wind from the north which made the ship almost unmanageable, tossing it first on one wing and then on the other in a vertical position, and twice putting it almost completely on its back. Nevertheless, he kept on to the south with the sight of land obliterated by the storm under him until he was finally forced down by the lack of gasoline. His report reads:

There were no dry spots to land on, and the ship turned over on its back. Sergeant O'Connor, my passenger, cut his lips and bruised his body and both right and left shins. I suffered only a bruised body. Realizing that nothing could be done with the ship and that it was impossible to right it and take-off at this place, we started walking in a northeasterly direction.

The territory in which this landing was made is known

as the Everglades. Its sameness is almost appalling; just one small cypress hummock after another; water and muck everywhere; innumerable mosquitoes, alligators, water moccasins and black snakes. Here and there a hummock would be found with a rock base and on some of these rock bases Seminole Indians eke out an existence. After landing, we walked to one of these hummocks, and as it was getting dark, collected a small amount of dry wood and built a fire, endeavoring to keep the mosquitoes off and dry our clothing, which could not be removed on account of the mosquitoes which attacked us in hordes. But we could find no Indians. Meanwhile, we had drunk no water for fear it might be infected with malaria germs or some other swamp fever, nor had any food been found. After passing a miserable night, we started a little before daybreak to drill through the knee-deep muck and continued in a northeasterly direction all day. Finding no suitable hummock, we were compelled to spend the night again in the swamp, this time on ground covered with an inch or more of water. By this time we were so nearly exhausted that we took a chance on the water, but due to lack of food we were rapidly approaching starvation.

The next morning we resumed our way through the muck again, starting before daylight, and at ten thirty a. m. sighted a flag flying over a hummock not far off. We found this camp inhabited by Seminole Indians. By sign language we succeeded in conveying to the Indians our need of food and after our meal managed to make them understand that we wished to reach Miami. They provided a "glade boat," which is made of one large cypress tree trunk hollowed out and propelled by a pole some fifteen feet long with a V-shaped foot on one end of it. After being poled through a perfect maze of waterways, we reached the dredge at the end of the Tampa-Miami Trail, where we were given food and a good bed and could wash the muck and dirt from our clothing and bodies. The next day a motor boat took us down the canal and further along we hired a Ford which took us to the flying field in Miami, arriving there at noon Sunday.

From Miami an attempt was made to salvage the ship by means of a caterpillar tractor which was carried to the edge of the Everglades on a canal boat, but the equinoxial storms setting in put the whole swamplands under water and this attempt had to be abandoned in favor of an expedition in "glade boats" furnished by the Seminoles. In this manner a number of men with food and gas for the engine, together with spare parts, were taken into the swamp, and after four days' travel reached a point a few miles from the ship where a base camp was established. Eventually a more secure rock base was located within three miles of the airplane and after chopping a track through the swamp the salvage party, by means of planks and cables, moved the airplane to the rock base. The motor, however, could not be turned over, due to its submersion in the water for three weeks. Indian "glade boats" were again dispatched to Miami for engine parts, together with a "trouble-shooter" from the nearest flying field. Upon the arrival of the mechanic and his tools the motor was finally started and with the engine roaring and the propeller droning a new tune to the startled Seminoles, the ship took the air once more. In a comparatively few minutes it was landed at the Marine Field, Miami, for gas, overhauling and repairs.

A rather different experience befell Lieutenant Albert O. Spencer, whose plane, when flying with eight others, suffered a break in the gas line when nearly 10,000 feet up and when the earth had not been visible for 45 minutes. The report says:

Forced to spiral down through several layers of clouds and rain to a level of about 1,000 feet before the ground became visible, he found himself over a town and was obliged to make a forced landing in a vacant lot. This drew a crowd of curious inhabitants and to avoid hitting the more venturesome who ran across his path, he made a sharp turn, colliding with a telegraph pole, damaging a wing. With the aid of two broom sticks and some muslin,

temporary repairs were made and the gas lines having been repaired, resumption of the trip was possible.

The lot was hardly large enough for a good take-off, but, by squeezing between telegraph poles, the pilot was able to get a run through a corn field and take the air with barely enough clearance to jump a big warehouse up-wind from him.

Assurances from the townspeople had led Lt. Spencer to believe Birmingham was only a few miles distant, but it had already grown dark before the lights of the city came into view. Again difficulty in finding a landing place was experienced, but having picked out a black spot which appeared to be cleared land, Spencer leveled out for a three-point landing. A few feet off the surface of his black spot, he suddenly discovered that particular surface to be water and he was in the middle of a good sized pond. He "zoomed" just in time to keep his tail planes out of the wet, climbed about 300 feet and began a circle of the city searching for the other ships. He met with no success in this effort and again picked out another spot for a landing. This appeared to be a vacant lot. Again he settled to the street level and flattened out, when to his surprise instead of feeling ground beneath him, he kept on settling and finally brought up in an excavation 20 feet below the level of the lot and stopped on the brink of a ditch which was invisible until disclosed by the headlights of an automobile in the street above him.

A military transcontinental fight in formation was made in December, 1918, by a squadron of four planes, each carrying two men. They left San Diego, California, on December 4 and arrived at Jacksonville, Florida, on the 22d, having flown approximately 2,400 miles in short flights limited by the size of their gasoline tanks, which carried no more than an hour and a half's supply. The total flying time was 55 hours. As they proceeded they gathered data of landing fields and mapped a complete southern trans-

continental air route. This work was a part of a big aerial reconnaissance being made by fliers going out in all directions from over 25 fields in various parts of the country, all contributory to the mapping of a network of air routes between important centers covering the entire country.

As American aviators were going far and wide, so they were also going high. New reaches and stretches of land tempted their imagination not more than the fastnesses of the upper skies. If some men went far afield, others were tempted on and on upwards. This had its very practical value, for the effect of thin air and the efficiency of oxygen tanks had to be well proved. A test of the latter was made in Chicago on September 8, when a De Haviland-4 plane, piloted by Lieutenant M. B. Kelleher, climbed to 23,000 feet, where a temperature of 17 degrees below zero, Fahrenheit, was encountered. The oxygen apparatus functioned well, allowing easy breathing. An idea of the power of an airplane is given by the fact that the ascent of 23,000 feet was made in 25 minutes, nearly 1,000 feet a minute.

It remained, however, for Captain R. W. Schroeder, to reach the highest altitude. His record of nearly 29,000 feet over Dayton on September 18, 1918, almost five miles above the ground and higher than the world's highest mountain, has been officially confirmed. His report of his sensations and the effects of a temperature 32 degrees below zero, Centigrade (about 23 degrees below, Fahrenheit), says:

The cold thin air is one's greatest adversary. First of all, one must make a study of the performance of his motor at these high altitudes. I took off at 1:45 p. m., Wednes-

day, September 18th, 1918, and made a steady circular climb, passing through clouds at 8,000 feet, 12,000 feet and 16,000 feet. At 20,000 feet, while still climbing in large circles, my goggles became frosted, making it very difficult for me to watch my instruments. When I reached 25,000 feet I noticed the sun growing very dim, I could hardly hear my motor run, and I felt very hungry. The trend of my thought was that it must be getting late, that evening must be coming on, but I was still climbing, so thought I might as well stick to it a little longer, for I knew I could reach my ceiling pretty soon, then I should go down and even though it were dark, I could land all right for I had made night landings many times before, and so I went to talking to myself and this I felt was a good sign to begin taking oxygen and I did. I was then over 25,000 feet and as soon as I started to inhale the oxygen, the sun grew brighter again, my motor began to exhaust so loud that it seemed something must be wrong with it, I was no longer hungry and the day seemed to be a most beautiful one. I felt like singing with sheer joy as I gazed about through the small portion of my goggles which had no frost, due to a drop of oil which had splashed on them from the motor.

It was wonderful to see the very clear blue sky with the clouds thousands of feet below. The frost on my goggles bothered me very much. At times I had to remove my glove in order to put the warm palm of my hand on the glass to thaw the frost. I did this about every ten minutes so that I could take the proper readings of the instruments, which I marked down on my data pad. I believe that if my goggles had been better ventilated, they would not have frosted. When I was about 27,000 feet, I had to remove my gogles, as I was unable to keep a steady climb. My hands, by this time, were numb and worried me considerably. The cold raw air made my eyes water and I was compelled to fly with my head well down inside the cockpit.

I kept at it until my oxygen gave out and at that point I noticed my aneroid indicated very nearly 29,000 feet. The thermometer showed 32 degrees below zero, centigrade, and the r.p.m. had dropped from 1,600 to 1,560. This is

considered very good. But the lack of oxygen was affecting me. I was beginning to get cross, and I could not understand why I was only 29,000 feet after climbing for so long. I remember that the horizon seemed to be very much out of place, but I felt that I was flying correctly and that I was right and the horizon was wrong.

About this time the motor quit. I was out of gasoline, so I descended in a large spiral. When I descended to about 20,000 feet, I began to feel much better and realized that the lack of oxygen had affected me. I passed down through the clouds at 16,000 feet and as I remember, it was snowing from these clouds upon the next layer, some 4,000 feet below. I am not positive of this as I may have been affected by the lack of oxygen. I noticed as I descended that the air seemed very thick and stuffy, but very nice and warm. I did not see the ground from the time I went up through the clouds above Dayton, Ohio, until I came through them again at 4,000 feet above Canton, Ohio, over 200 miles from where I started.

Special stunts, although allowed only in unusual circumstances, became more bold as skill and knowledge increased. One of the most unusual was that of Lieutenant William T. Campbell, who made 102 consecutive loops from a height of 10,000 feet at Love Field. Several men jumped from planes in flight to test the practical use of parachutes. Chauffeur R. W. Bottriell on October 15, 1918, with the engine stalled by his pilot and the plane banked so as to allow him to clear the tail, jumped over the side at 4,800 feet altitude with an American flag flying from the parachute, and judging the distance nicely in the strong north wind, landed squarely in the main flying field.

Fast flights also became common. On July 31, 1918, a flight from New York to Washington in two

hours and 15 minutes through rain and mist was made by Major C. K. Rhinehart and Captain Fred Harvey. In early October a De Haviland plane flew the 430 miles from Dayton, Ohio, to Washington in two hours and 50 minutes at a speed of 143 miles an hour, against 16 hours and 10 minutes for the fastest train. On November 29 General Kenly flew from Washington to New York in a De Haviland plane in one hour and 55 minutes, and on December 6 a Glenn Martin bomber flew the 191 miles airline from Pittsburgh to Washington in 75 minutes.

The uses of planes continually increased. For the first time in the country's history, soldiers under orders for duty were transported by airplane on September 7, when 18 enlisted men were taken from Rantoul to Champaign, Illinois; shortly after a ruling was made that expenses should be allowed for airplane travel at the rate of four cents a mile, as is allowed for transportation by prairie schooners, Alaska dog sleds, and Philippine buffalo carts. After the explosion of the Gillespie shell-loading plant at Morgan, New Jersey, a plane hovering only 1,000 feet above 8,000,000 pounds of T. N. T. was able to detect lanes of fire leading from the demolished loading sheds to the T. N. T. plant, direct the firemen through the openings between the walls of fire and wreckage, and help greatly to check the flames and probably avert the added horror of a T. N. T. explosion. A new record for passenger carrying was established by the Navy in December, when its giant seaplane C-1, with three Liberty Motors, took up 50 men.

A very noteworthy event was the opening on May 15, 1918, of the first regular aerial mail service in the

United States. The Army furnished six planes and pilots, shortly doubled, for a daily round trip between New York, Philadelphia and Washington, carrying about 350 pounds each way, with a flight record of 50 minutes for the 90 miles from Philadelphia to New York and one hour and 50 minutes for the 135 miles from Philadelphia to Washington. Very shortly 100 per cent. efficiency of delivery at less than one-half train time was established, and the postage rate was reduced from 24 cents a letter to 16 cents and then to six, omitting the special delivery.

On August 12 this work was formally taken over by the Post Office Department, which meanwhile had secured civilian fliers. Additional planes were secured as fast as possible under the restrictions imposed by military necessity, and arrangements were made to take over a large number of battle planes and bombers at the end of the war. Plans for a very large extension of the service were announced,[2] including a route between New York and Chicago with a time of nine hours as against 21 by train, and every confidence was expressed that on these long flights, where overhead charges for terminals would be very small, the aerial mail would be not only over twice as fast, but very nearly as cheap as rail mail with its expenses for trackage, terminals, and upkeep.

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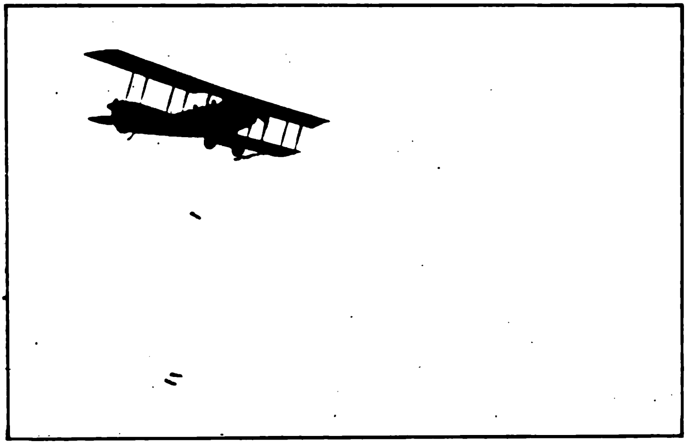
[2] The Postmaster-General's annual report, issued in December, suggests a much more elaborate programme comprising four trunk lines: (1) New York to San Francisco, with feeders from Chicago to St. Louis and Kansas City, Chicago to St. Paul and Minneapolis, and Cleveland to Pittsburgh; (2) Boston to Key West, with feeders from Philadelphia to Pittsburgh, Washington to Cincinnati, and Atlanta to New Orleans; (3) Key West, *via* Havana, to Panama; (4) Key West, *via* West Indies, to South America.



BOMB DROPPING AT THE TRAINING FIELDS

NIGHT FLYING AT THE TRAINING FIELDS

Most amazing of all recent innovations in aerial work, however, was the development of the control by actual human voice of a large squadron of planes. This was made possible by the perfection of the radio telephone to a point where the commander of a squadron can direct his fellow aviators through all evolutions. By this means a fleet of planes flying perhaps on several different levels can be turned to the right or left, upward or down, just as freely as the commander of a company of infantry can put his men through drill.

Very early, indeed in 1910 at the International Aviation Tournament at Belmont Park, the importance of controlled formation flying was recognized by Army officers who saw a squadron of 11 monoplanes, one of the first in history, come swooping towards them in a group from over a grove of trees. The following September the development of radio-telegraphy was begun at San Diego, with the ultimate hope of developing also radio-telephony. By 1916 wireless telegraphy had come to a point where airplanes in flight could communicate with each other over a few miles and with the ground over a distance of 140 miles.

In February, 1917, two months before this country entered the war, the first successful experiments with aerial radio-telephony were made by Colonel C. C. Culver; communication was then established with the ground over a distance of a few miles. The pressure of war, with its great aerial programme, gave added impetus to this work. Beginning with a conference on May 22, 1917, between Army radio officers and large commercial interests, developments became much

more rapid, until in May, 1918, extended tests were begun at Gerstner Field which continued through June and July. During these tests an official inspection was made by the Director of Military Aeronautics. A command of 39 machines formed into two squadrons of 18 planes each, with the thirty-ninth plane carrying the commander, had been carefully drilled and made ready. When General Kenly arrived, the command was formed in the air into a single formation, proceeded across a distant part of the field in column, executed "column left," and then in sections passed before the reviewing stand. A fast close-order drill then followed which showed absolute control of the planes by voice.

Ability to hear the human voice above the noise of the motor depends upon the fact that noises produced by the motor have a vibration frequency of less than 200 per second, while the vibrations of the human voice range from a little over 200 to as high as 3,000. The transmitter is so constructed as to exclude all sounds below a frequency of 200 and the receiver so built into the aviator's helmet as further to exclude external noise. Pilots who do not send but only receive commands are equipped only with a receiver but are able to answer their commander's questions by dipping their planes forward for the affirmative and sideways for the negative.

In all formations machines are echeloned in altitude from front to rear, the leading machines being the lowest. In all line formations machines are echeloned in depth. Individual flank movements are made, not on a given radius, but with the machine banked 45 degrees. The preparatory command is

given twice, followed by the command of execution, "Go." Many times towards the end of the war officers sitting in the radio room in the Division of Military Aeronautics building in Washington listened in as a squadron commander several thousand feet above the Capitol ordered his companion aviators to wheel this way or that or perform other evolutions.

This, of course, provided the final word in aerial tactics, and forecast squadrons of many types of planes flying in different strata and for different purposes, but manœuvring like a high-seas fleet of battleships, cruisers and destroyers. There might thus be, for example, a first flight flying at about 12,000 feet, a second flight 2,000 feet above and 800 feet behind to fly down to the protection of the first, and a third flight another 2,000 feet above and slightly behind the second to guard both top and flank. This would enable immediate concentration, either from above or below, at any threatened point, with ability to manœuvre in absolute unison in response to voice commands.

CHAPTER XV

THE BALLOON SERVICE

The balloon service a necessary consort of aviation — History of military ballooning — Its neglect in the United States — Its development through the European War — Service, duties, and dangers of balloon observers — American balloon service at the outbreak of war — The war programme — Training of personnel — Schools at Fort Omaha, Camp John Wise, and Arcadia — French ballooning system adopted — Courses for observers and manœuvring officers — Arrangements for telephonic communication — Officer personnel at the termination of hostilities — Balloon design — Difficulties and results of production — Production of helium gas in balloon quantities — Total personnel and overseas personnel at the signing of the armistice — Transformation school in France — The balloon service in action.

A vitally important element of the Air Service, quite distinct from the work so far described, yet collaborating with it most effectively in the collection of military information, is the balloon service. Less spectacular perhaps than the heavier-than-air branch, a balloon service is an indispensable adjunct of any army in the field, and it carries out a duty which could be accomplished by no other means, especially under the new conditions of trench warfare. Like its companion service, ballooning had an enormous development through the Great War.

Ballooning antedates aviation proper by several centuries; it represents, indeed, man's first attempt to learn from the skies the plans of his enemies. In the Napoleonic wars France used balloonists against Austria, but so revolutionary was the procedure, and so out of keeping with the ideas of warfare then pre-

vailing, that Austria treated all captured balloon observers as spies fit only for the ignominious death reserved as a penalty for illegitimate warfare. During the Civil War in the United States Northern observers looked out across the Potomac from near Washington at the Confederates on the other side, and secured very valuable information, though under the most precarious of conditions. France further developed the art in the war of 1870 against Germany, but it remained for the latter nation to bring it up to its highest development in her monster Zeppelins. Except in Germany, however, the science of ballooning fell upon slack times, as did aviation itself in Germany. While that nation proceeded with the development of her ungainly airships, the other nations were inclined to see in them something of the heaviness and stolidity usually associated with the German character, and as a result devoted themselves to the more romantic and the more scientifically challenging subject of heavier-than-air work.

In the United States especially was this true. With the American military establishment cut almost to the bone, ballooning was reduced bit by bit until before the war it had practically ceased to exist. For the first decade of the present century the War Department's reports contain recurrent statements that no work was done because of lack of funds. With the almost negligible sums voted by Congress for aviation as a whole, the less stimulating and less promising branch of the Air Service was entirely neglected.

The war in Europe quickly reinstated ballooning in the important position to which its potentialities as a

means of securing vital information as to enemy movements entitled it. This was especially so the moment the war became a war of position, for it was found that balloon observers could ferret out information through their painstaking examination which was denied to their very much fleeter and consequently more transitory fellow observers in heavier-than-air machines. Hence, there developed rapidly a system of ever-watchful sentries, swinging below their ungainly gas bags two to five miles from the enemy's lines and at altitudes up to a mile, covering every sector of the front from the North Sea to the Adriatic. A constant vigil was maintained over every move of the enemy and over every shell fired by either side, so that friends below might be saved from surprise and enemies beyond might receive the maximum of damage.

The balloonist, with a range of vision of about eight miles in every direction, was able to make a far more detailed, minute-by-minute analysis of the enemy's movements than the airplane observer, though of course in a very much more restricted field. Every movement within the enemy's lines, no matter how slight, was registered until a detailed schedule of the usual enemy routine was built up and the average amount of movement known. Any departure from this schedule at once became suspect. A train running late or with more cars than usual, men in the trenches being relieved too frequently, new roads or emplacements being built with too much earnestness, might easily give the hint that the enemy was planning some new move.

A keen balloonist, of course, would note any such

minute details, which very possibly would escape the airplane observer, especially as the latter might be engaged in work far behind the enemy's lines. He would perhaps telephone down to the ground, for all the balloons were connected by telephone, that "an extra train of six cars passed —— at 10:40." Half a mile further down the line another observer might report "a large convoy moving up to the front, range so and so," while still further down another suspicious circumstance might be noted, until the General Staff below, adding together all these scraps of information, could foresee the beginning of a major movement across the lines and make plans to break it up. The airplane observer meanwhile would be taking photographs of the suspected points and penetrating far back into the enemy's service of supply to determine whether the movement were purely local or general.

For hours at a time the balloonist would ride in his basket with the enemy lines spread out before him and with the intelligence officers below in direct telephonic communication. The moment artillery action began on either side a new phase of his work opened. If it were enemy batteries going into action, he would have to line out as nearly as possible their exact location, possibly in triangulation with other sources of information, and tell by their fire of what calibre and how many in number were the guns. He was expected to know his front so well that no new battery could come into action without his spotting it immediately and furnishing the information that would lead to its demolition. So also in case of his own batteries going into action, he had immediately

ditions were thought to be peculiarly favorable for balloon ascensions. Great uncertainty existed at first as to the courses to be taught at these schools, as there was an almost complete lack of information as to the practice in foreign armies. At first attention was equally divided between captive and free ballooning, but with the arrival of British Royal Flying Corps officers in June, 1917, the course was made to conform with the British practice, with particular attention paid to artillery observation. When in October, however, the Artillery practically decided to adopt French methods, the French system of ballooning was added, and the two courses, French and British, continued concurrently until April, 1918, when the French system was made the exclusive course.

As finally operating the officers' course began with 10 weeks of ground instruction at Fort Omaha, followed by two advanced courses of six weeks each, one for observers at Arcadia and the other for manœuvring officers at San Antonio, the latter being the ground officers who handled all the work in connection with sending up balloons, manœuvring them as to winds and enemy attack, and handling their equipment and crews. In general the subjects taught included map reading, artillery observation, telephones and communicating lines, rigging and repairs, the winch, hydrogen, the theory of ballooning, and, above all, meteorology with all its details of atmospheric pressure, movements of air, precipitation areas, storms, and instruments.

Arcadia developed into perhaps the most interesting school, with some quite unusual features. A total

of 106 miles of wire were in use there to teach military communication, strung exactly as it would be at the front, with communication posts and stations for all kinds of messages, and covering a large part of the surrounding country. All the balloons when aloft were so wired that they could be linked together with any trench, doubled up for work together, or cut off so that each talked only with its own chart room, winch, or operating crew on the ground below. What was thought to be the highest wireless aerial in the world was operated there by means of a cable from a balloon; it intercepted messages from the Brooklyn Navy Yard.

Up to the termination of hostilities a total of 598 officers were graduated from these schools, including 379 from Fort Omaha, 128 from Camp John Wise, and 91 from Arcadia. Another 370 were in attendance, while various detachments had been sent at different times to Fort Sill, Fortress Monroe, and other artillery firing centers for the training of artillery officers in coöperating with balloons.

The problem of equipment presented difficulties, as there was neither a satisfactory type available here nor factories trained in this specialized manufacture. During the Mexican trouble in 1916 there had been but one balloon in the service of the army on the border, that a gift to a National Guard battery and of amateur design.

Up to the beginning of the European War there had been the greatest difficulty in securing a balloon that did not sway and bob about in the air to an extent inconsistent with exact observation. Captain Caquot of the French Army, however, developed a new type

with a gas bag larger in diameter at the nose than at the tail, which made it head into the wind, and with a rudder at the tail which kept it from rocking and pitching. The maximum diameter of the balloon was approximately 28 feet, its capacity 1,000 cubic metres, or 35,000 cubic feet, and its power of ascension conferred by hydrogen gas.

The reproduction of this type here, however, presented unexpected difficulties. The manufacture of balloon fabric had been only partially developed in this country, and considerable time was required to get it in full swing. Factories with sufficient free and open floor space and a complete absence of dirt and dust were not readily available. The essential speed was so difficult to obtain with the untrained labor force that a number of experienced men and women were brought over from France to act as instructors. Nevertheless, by November 11, 1,167 balloons were on order and 507 had been delivered, of which 119 had been sent to the training schools and 333 actually embarked for overseas, more than sufficient to meet American needs there. In addition, 2,482 tons of ferro-silicon and 947 tons of caustic soda, 89,125 hydrogen cylinders, 48 winches, and 1,172,000 feet of cable had been turned out, of which a considerable portion had been embarked.

America made one contribution to military ballooning of the greatest importance, though not in time to affect the course of events in Europe. It was thus described by General Squier before the American Institute of Electrical Engineers on January 10, 1919:

One of the greatest scientific achievements of the present war from a technical standpoint is the production of helium

THE CAQUOT BALLOON ASCENDING; THE TRIPLE-LOOPED TAIL IS INFLATED BY THE WIND, AND NOT ONLY KEEPS THE HEAD TOWARD THE WIND, BUT BY MEANS OF A DIAPHRAGM ARRANGEMENT INSIDE THE BALLOON KEEPS THE MAIN GAS BAG RIGID EVEN WHEN MUCH OF THE HYDROGEN HAS LEAKED OUT

in balloon quantities. This gas is non-inflammable and has about 92 per cent. of the buoyant effect of hydrogen. Its name is due to its having been discovered in the sun's atmosphere through a characteristic line in the solar spectrum, before its presence on the earth or any of its properties were known. It first was obtained in minute quantities by Ramsay in England some twenty years ago by heating certain radioactive minerals, in which it occurs because it is a disintegration product of radium. Its pre-war scarcity may be appreciated from the fact that up to two years ago, not more than 100 cubic feet ever had been obtained, and the usual selling price was about $1,700 a cubic foot.

Notwithstanding so discouraging an outlook someone in the British Admiralty had imagination enough to propose the large-scale separation of helium from certain natural gases in Canada, that contain about one-third of one per cent. of it, and experiments were undertaken at the University of Toronto. Soon after the entry of the United States into the war, the Bureau of Mines, learning of the problem from a British confidential memorandum, persuaded the Signal Corps and the Bureau of Steam Engineering of the Navy to approve and finance jointly an experimental programme on a large scale. Thanks partly to the unusually rich sources of supply in this country, and partly to the skill of the two commercial companies whose services were enlisted, and to the enthusiasm of the Bureau of Mines staff and of Mr. Carter, of the Navy, who for a time represented the Army as well in the project, such success was achieved that, at the cessation of hostilities, there was compressed and on the dock ready for floating 147,000 cubic feet of nearly pure helium, and plants were under construction to give at least 50,000 cubic feet a day at an estimated cost of not more than ten cents a cubic foot.

The production of a balloon gas that assures safety from fire opens up a new era for the dirigible balloon. In November, 1917, a Zeppelin made the trip from Bulgaria to German East Africa with twenty-five tons of medicines and munitions only to find that the German forces already

had been dispersed, and returned safely to its base without landing. With a non-inflammable gas, not only comfortable and expeditious, but also safe trans-continental and trans-Atlantic travel in dirigibles will, it is believed, soon be commonplace.

The overseas demands for balloon personnel and equipment increased steadily as time wore on in much the same way as demands in the heavier-than-air field. The A. E. F. programme of September 18, 1917, called for a total of 69 balloon companies overseas, with eight shipped each month beginning in January, 1918. The general authorization for the Division of Military Aeronautics approved on May 29, 1918, allowed for a balloon force of 14,467 officers and men. As the overseas requirements, however, called for 13,800 of these men, authority was asked on July 17 for 30 more companies to allow the training and artillery-coöperation work in this country to continue. This was granted on August 12, and adding 240 officers and 6,000 men to the strength authorized.

On June 30, 1918, the actual strength stood at 9,621 officers and men, with 1,382 sent overseas. From then on overseas demands increased steadily, 44 companies being called for in August and 30 in September, with a total to November 11 of 107, as against the original schedule of 69. Up to the signing of the armistice 25 companies had actually been sent overseas, with a total personnel of 223 flying officers and 10 non-flying officers, 131 Artillery officers attached, and 6,475 men. Similarly the total strength here and abroad had jumped to 685 flying officers, 66 non-flying officers, 156 Artillery officers attached, and 16,549 men. Despite this great in-

crease, however, the men had not been received in time to meet the requests from overseas.

As in the heavier-than-air service, a special training system was developed abroad to "transform" men from this country by means of training under actual war conditions. To this end a balloon school was established in France both for observers and for enlisted men. By the termination of hostilities 157 officers had been graduated and 48 were still in attendance, while of enlisted men there had been graduated 174 machine gunners, 68 winch operators, 63 chart-room clerks, 58 telephone experts, and 55 radio operators.

Although this force came to the front but gradually, the balloon service may be said to have proved itself at Château-Thierry, as did its companion heavier-than-air service. Only three hours after the American infantry had entered the city in the beginning of its offensive, a balloon company of 170 men and its equipment entered; next morning it had a balloon up five miles beyond, observing for American artillery, with a complete line of communication established. Another balloon company, a few hours behind the first, got into action closely after and brought down an enemy airplane with a captured machine gun, for which a citation in French Army orders was given it. Another company, so heavily shelled that it had to haul down its gas bag, transferred its whole equipment to the other side of a forest 14 acres in area and continued its work uninterrupted. Several other companies were mentioned in orders, one because, "despite the fact that shells were falling on all sides of the balloon, two so

close as to tear holes in the fabric, no man left the ropes nor faltered."

Many balloon observers found safety when their balloons were set on fire by enemy planes only by climbing out and jumping off into space with their parachutes. Lieutenant James A. McDevitt, for instance, was cited as follows:

Four jumps: September 17, 1918, at Memey, Lieut. McDevitt jumped when attacked by enemy plane. October 5, 1918, Lieut. McDevitt jumped during the advance northwest of Verdun. There were eight holes in the balloon and four in the basket from the enemy's bullets. October 6, 1918, Lieut. McDevitt, while observing in a balloon was attacked by two enemy planes and forced to jump. Eighteen minutes later he ascended and continued his work. October 6, 1918, Lieut. McDevitt was attacked the second time and an hour and eight minutes later. He jumped. The balloon was burned.

So also Lieutenant George D. Armstrong was credited with three jumps, the second on October 6 when he was attacked by two Fokker planes, followed immediately by a reascension and another jump 13 minutes later.

The first fatality in this work was that of Lieutenant C. J. Ross in October. Lieutenant Ross was on a special mission during a day of overcast skies, when suddenly, during an intense bombardment which he was directing, a German air squadron appeared out of a cloud bank, dived for the balloon and set it on fire. Ross's companion had some trouble in getting out of the basket, and Ross delayed to see him clear before he jumped himself. The delay proved fatal, as his parachute in its slow flight was

BALLOON CREW AT THE GAS CYLINDERS CONNECTED WITH THE FEEDING TUBE

PILOT AND ARTILLERY OBSERVER IN BALLOON BASKET WITH TELEPHONE EQUIPMENT AND PARACHUTES IN STOPS; EACH PARACHUTE IS ATTACHED TO THE MAN WHO MAY HAVE TO USE IT

overtaken and ignited by burning wreckage from the balloon.

All during this time both equipment and men became available in ever increasing numbers, so that by the time hostilities ended America was well represented in ballooning at the front, where Colonel Charles de F. Chandler was head of the Balloon Service, A. E. F. Up to November 6, 251 balloons had been received from the United States, of which 10 had been given to the French and 15 to the British; 23 had been lost by burning or condemnation, 16 were at the training fields, and 81 in the zone of advance, and 106 were stored. During the week of October 30, 17 balloon companies were actually at the front and flew a total of 54 hours. Of the 405 officers with the service in France, 201 were in the zone of advance. Ballooning, though less spectacular than the heavier-than air work, had fully proved its inestimable value in observation and direction of artillery fire.

CHAPTER XVI

THE STRUCTURE OVERSEAS

Course of the overseas development of the Air Service — Coördination of American and Allied resources — The development in France — Training of fliers — The flying field at Issoudun — Summary of Air Service establishments — The Romorantin assembly, repair and salvage plant — Establishments at Orly, Tours, and Colombey-les-Belles — Organization of the first squadrons — Equipment of the combatant squadrons and training fields with French and American planes — The development in England — Training of fliers — Their service with the Royal Flying Corps — Training of mechanics — The Anglo-American night-bombing agreement — Total personnel trained in England — The development in Italy — The situation at the termination of hostilities — The service of the American air force.

We now turn finally overseas, where American airmen wrote a chapter in the aerial history of the Great War which cannot be surpassed. The romance, the glory, and the skill associated with these picked young Americans will send a thrill of pride through their compatriots when time permits the full story to be told. Now only a hasty glimpse behind the curtain is possible.

America's aviation activities abroad, as in this country, had to be built from the very foundations. Long, weary months of development, of constructing fields, depots, and airdromes, of learning the very primer of flying, had to be gone through before even a handful of pilots appeared over the front. Vexations, delays, and cross purposes had their place there as in America, intensified further by distance from

home and presence among foreigners. All were forgotten, however, as the first enemy aviators began to go down before the young American flying force.

The entry of the United States into the war found the Allied nations with a magnificient aviation mechanism but largely stripped of personnel; the United States, on the other hand, had a superabundance of personnel without an operating mechanism. Three years of desperate strife had drained off the best flying material abroad, while years of isolation from the war's developments and a general public apathy had prevented the building of any structure here. Consequently, American aviators could take their places over the lines within any reasonable time only if they were admitted at once to Allied schools. Out of this situation of contrasts grew an inter-Allied coöperation of splendid efficiency. America provided of her strength in untrained personnel and in raw materials, while the Allies gave of their skill, experience, and plant. With admirable unity of purpose the joint forces were forged together to a common end, and to this dovetailing of resources may be largely ascribed the part that America played in the aerial warfare.

Little did anyone foresee at the outset what America's overseas aerial programme would be. As a matter of fact, there was created outside of the United States an organization which at the termination of hostilities was slightly larger in total personnel than that existing here. Its functions and work may be divided both by classes and by countries. First was the training of fliers, which was carried out in Canada, England, France, and Italy. Second was

the provision of enlisted personnel both in England and in France, for the purpose of relieving the depleted labor markets of the Allies and of training mechanics for eventual use with American forces. Third was the building of fields, airdromes, and plants and the assembly and upkeep of planes, engines, and other equipment. The three brought to the front all the parts essential to a splendidly balanced Air Service.

To begin with the development in France, the first modest start came with the sending abroad on May 27, 1917, seven weeks after the outbreak of war, of a small detachment of cadets who had had some slight flying training. This was in response to France's offer to train 60 men in her schools, and its quick acceptance by the United States led not only to a very great enlargement of France's offer but also to similar offers from England and Italy. As a result, other cadets followed rapidly — 491 by September 1, 1917, and 2,260 by February 1, 1918, the pick of America's young manhood, until finally 2,531 cadets had been sent to France while American schools were being filled with their classmates.

At the outset the majority of these men went to wholly French schools, but as American engineers and construction companies built up American schools overseas, they were shifted over until at the end of the war nearly all were in American institutions. For a time very many were idle because of the upsetting of the whole Allied aerial programme by the unexpected demands created by the Russian and Italian defeats and by the slow shipment of raw materials from the United States, but as the crisis

passed and a more normal course was resumed, deliveries of planes also picked up and with them the American training programme.

The number of men trained in France is surprising. Up to November 11 the schools of France had graduated a total of 8,114 pilots and observers, including 1,573 preliminary, 2,359 advanced, 1,160 pursuit, 723 observation, 329 day-bombing, and 25 night-bombing pilots, and 88 pursuit, 1,425 artillery, 390 day-bombing, and 142 night-bombing observers. A total of 1,853 graduates had been sent to the zone of advance by November 6, and 2,012 others were in training at the termination of hostilities. Up to November 6 there had been 148 fatalities in training and a total of 137,804 hours flown, or 931 hours to a fatality, as against 606 hours among American pilots in England and 2,960 hours in the United States. By November the schools in France had attained a capacity of about 2,000 pilots a month, and were frantically cabling to the United States to send over men who had gone through preliminary training for the final, or "refresher," work there. As the hostilities ceased, the system of giving all the preliminary work in the United States and the final work in France was becoming well established, and the early lack of cohesion between the two systems was being adjusted into a well regulated balance.

America's aerial building operations in France began almost equally early and equally modestly. Even before the advance guard of the A. E. F. sailed for France, arrangements to build an aviation school there had been made by the aviation authorities and approved by Secretary Baker on May 19, 1917. All

materials, including nine miles of railroad, were assembled in five weeks' time, and on July 16 three ships sailed from Hoboken laden with equipment to build barracks, mess halls, hangars, machine shops, water towers, and plumbing. Two days later the first detachment of aviation enlisted men, 200 in number, followed. Personnel and materials were brought together at Issoudun, France, and by September flying was in progress there.

This field at Issoudun became the largest in France, and also in the world. It was described as "a flying field of 36 square miles, the area of an American township, with nine separate flying fields on which American aviators advance to the stage of flight combatants, and airplanes, Liberties, Nieuports, Capronis, and all others, with officers, instructors and newly equipped aviators, swelling our squadrons each month." Its capacity was to be 1,000 planes, with 350 staff officers, 1,800 students, and 6,100 men, of whom 1,165 officers and cadets and 4,861 men were actually on hand on November 1. There were authorized 203 buildings for housing, 37 shops for storehouses, 84 hangars, and 15 miles of railroads and turnouts. At the termination of hostilities the Issoudun field, then commanded by Lieutenant-Colonel Hiram Bingham, had 14 flying fields and was the instruction center for the Air Service of the Third Army.

Meanwhile, other American aviation centers began to spring up all over France. Some were built by American engineers and workmen, others taken over from the French, until by the signing of the armistice the whole country was dotted with them. Besides

offices in London and at the A. E. F. headquarters at Chaumont, the central offices were in Paris, service of supply headquarters at Tours, and advance headquarters at Colombey-les-Belles; the Paris office was by far the largest, with over 400 officers, under command of Lieutenant-Colonel H. Dunwoody. Besides the flying school at Issoudun there were seven other schools: Tours and Chatillon-sur-Seine, for observers; Meucon, Souge, and Coetquidan, for artillery firing point; Clermon-Ferrand, for bombardment; and St. Jean-de-Monte, for aerial gunnery. In addition, there were six ports of debarkation, 20 airdromes, five organization training centers, three air depots, three supply depots, and one aerial-gunnery school, one warehouse, concentration camp, acceptance park, testing field, and assembly, salvage and repair depot.

Of these establishments that at Romorantin, under command of Lieutenant-Colonel E. V. Sumner, was most important, "a mammoth Air Service production center with huge shops and warehouses," as a correspondent described it, housing 305 officers and 6,775 men on October 29, 1918, and laid out to care for 25,000, with warehouses, motor-transport park, plants for fabricating day and night bombers and for repair and salvage, and three flying fields. Its construction had been approved by the Commander-in-Chief on December 27, 1917, and it was 74 per cent. completed on September 30, 1918. Assembly of American-built planes, repair of a score of different foreign motors and of all planes badly damaged, and salvage of all parts of planes and motors that could be reused were carried on here. As a correspondent wrote of the Romorantin establishment:

assembled, tested, armed, and all the other makes of cars are mobilized here preparatory to going into use on the flying fields and the front. There is, besides, the huge work of receiving the wrecked cars as they come here riddled with bullets, their wings torn off, which tell of a fierce contest. Such as can be made serviceable again are sent back to the field, while the wreckage of those beyond repair strews an immense field and is a ghastly reminder of the heroic sacrifice their pilots have made.

The process of assembling the cars as they come from America was followed through its various stages in the six huge "bays" of the workshop, each bay having a capacity of 18 machines or over 100 machines going forward at the same time. Nine huge boxes bring the different parts. First, the fuselage or body is set up, the motors installed, the landing wheels attached, the wings and tail adjusted, the gun racks and armament prepared, and soon a complete car ready for flight grows out of the scattered parts.

How many are turned out daily cannot be stated, but it can be said that the capacity of this big airplane center working in eight-hour shifts is 50 complete airplanes a day. And in these days, when the mobilizing of machines follows close on the mobilizing of men, the actual production is not far from the full capacity.

Orly also was an important center, where all planes received from the French, which for a long time were the only ones available, were tested and accepted by the United States. This project, made necessary by the congestion in French factories and authorized on March 19, 1918, contemplated a plant to handle 500 planes, with a force of 300 officers and 1,800 men. As a matter of fact, 280 officers and 2,232 men were at work on October 29, with construction work 85 per cent. completed on September 30. The Orly Acceptance Park was commanded by Colonel T. A. Bald-

placement Barracks, commanded by Colonel Aubrey Lippincott, where the complete organization and equipment of the squadrons was carried out, except the planes, which were flown to the advance stations by the pilots from Orly.

Tours, in addition to being S. O. S. headquarters, was also a large training center with its school taken over from the French on November 1, 1917, when it had a force roughly of 20 officers, 100 students and 450 men. The United States at once arranged to triple its size, and the Air Service had the construction work 95 per cent. completed on September 30, 1918, and a force of 844 officers and cadets and 2,660 men installed on October 29. The Chief of Training, with headquarters at Tours, was Colonel W. S. Kilner.

Also at Tours was the headquarters of the Air Service overseas. At the termination of hostilities the overseas force was commanded by Major-General Mason M. Patrick, Chief of Air Service, A. E. F. His Assistant Chiefs were Brigadier-General William Mitchell, Army Group, or zone of advance, and Brigadier-General Benjamin Foulois, Service of Supply. The commanders of the army groups were Colonel Frank P. Lahm, First Army, and Colonel Thomas DeW. Milling, Second Army; when the Third Army Air Service was organized, General Mitchell took command.

Colombey-les-Belles was headquarters of the First Air Depot in the zone of advance. Approved as early as September 29, 1917, and a complete project submitted a month later, it was 94 per cent. completed on September 30, 1918, and had a force of 396 officers and

3,050 men on October 29. This, of course, was the operating base of the Air Service squadrons at the front, whence orders to the actual fighting force were issued.

In due time all this preparatory effort in the rear began to show on the front. First as detachments or individuals brigaded with the French and later as complete American units, the personnel began to move out to the zone of advance, a stream small at first but steadily mounting to great power. The first squadron, the 12th Observation, was reported completed on March 6, the 94th Pursuit on the 7th, the 90th Observation on the 22d, and the 103d Pursuit on the 29th. April saw completed the 93d Pursuit and the 89th and 99th Observation on the 11th, and the 1st Pursuit on the 17th. May saw completed the 88th and 91st Observation, and the 147th and 27th Pursuit; June, the 139th Pursuit; July, the 13th, 49th, 93d, and 213th Pursuit, and the 24th and 104th Observation; a total of 23 squadrons in five months.

The provision of equipment was a very serious problem. For over a year the large American training schools in France and the men at the front were entirely dependent upon foreign planes. From the French alone, for instance, 18 different planes totaling 14,378 machines had been ordered, and 15 different motors to a total of 48,846, with deliveries of actual combat planes to November 6 totaling 2,676. On October 30 there were with combat units 305 pursuit, 336 observation, and 87 bombing planes, while 10 days before there had been at fields 891 training planes in commission, 695 out of commission, and 654 in reserve, a total of 2,968 planes of all types. The total

number of planes received by the A. E. F. from all sources up to November 16 was 6,472.

Of the 43 squadrons on the front on October 31 (there were two more by November 11, one night-bombing and one night observation), 20 were monoplace pursuit, including 17 equipped with Spads and three with Sopwith-Camel; 17 were observation, including 11 equipped with Salmson, five with American De Haviland-4, and one with Breguet-A2; six were day bombers, including five equipped with American De Haviland-4, and one with Breguet-B2. Eleven more squadrons were equipped and waiting to go to the front and another 10 were being mobilized.

This shows that despite all the delays in American production, 10 of the 43 American squadrons on the front on November 1 were equipped with American De Haviland planes. With the first of this type received in France in May, 157 had arrived by July 1, 377 by August 1, 661 by September 1, 853 by October 1, 1,185 by November 1, and 1,379 by the termination of hostilities. Of these there were actually in the zone of advance six by July 1, 64 by August 1, 180 by September 1, 494 by October 1, and 582 by November 1. In consideration of the fact that the total French strength was set at 2,820 and the total British strength at 1,664, these figures are very considerable, and indicate plainly that if the war had continued, American equipment would have taken a very important place within a few weeks.

In addition, of course, a mass of other supplies was received, including instruments and accessories, machine guns and ammunition, and bombs. In the single week of November 6, 14,949,541 pounds of this service

material was received at the ports of debarkation. All this had its place in building up the service of supply necessary both to equip new planes and to repair those that had been over the lines. In the single matter of motors, for instance, a total of 2,188 Liberties had been received at Romorantin for testing, in addition to the first of the Hispano-Suiza engines.

All this time a smaller but not dissimilar organization was being built up in England. As with France, cadets were sent over early in response to a cable of August 28, 1917, that "200 cadets can be taken for training in England." In all, nearly 400 were put into British schools on the same status as the British themselves, with total graduations of 316 men, including 157 pursuit pilots, 129 day bombers, 23 night bombers, and seven observers. A rough basis of comparison as to the relative danger of the British and American training systems is given in the fact that to October 9, 1918, 34 Americans were killed in accidents with only 20,624 hours flown, or a death to every 606 hours. This, admitting the far more advanced training given in England and the encouragement to test skill by running risks in flying close to buildings and making dangerous landings, shows the American rate of one accident to every 2,960 hours flown to be relatively favorable. In this training 18 different planes were used, as against not a third that number here.

Of the 316 graduates sent to France, 102 were delivered to the A. E. F., the cost of training, it is interesting to note being figured at £1,000. The other 214 men were attached to British squadrons, where they were shown in the Royal Flying Corps reports to have

AN AIRDROME OF THE AMERICAN AIR SERVICE IN FRANCE

done magnificent work, though at a very heavy toll. A total of 95, or 44 per cent., had been put out of action by the termination of hostilities, including 23 dead, 25 missing, 18 wounded, 23 prisoners, one interned, four discontinued, and one transferred. This total figured against the number of days of service gave the average period of usefulness of a pilot as but 68 days.

England also served as a great supply and mechanics' training center. On December 5, 1917, an agreement was made to maintain a force of 15,000 American mechanics there, bringing in new men from the United States all the time and sending on to France those who had become proficient. England derived great benefit from this arrangement through an increase in her seriously depleted labor supply and a stimulation of its morale, while America secured the advantage of having these men trained in the best British factories and airdromes and with actual service planes before going to the front. The programme was delayed somewhat; 951 men were delivered by January 1, as against 4,000 agreed; 1,375 by February 1, against 9,000 agreed; and 3,931 by March 1, against 15,000 agreed. By April 1, however, the number jumped to 10,819, with 13,470 by June 1, 16,224 by September 1, and 16,092 on November 13. In addition, 6,200 carpenters, bricklayers, and general laborers were to be provided for building airdromes and fields, of whom a total of 3,643 were on hand. An armorers' school was in operation at Uxbridge, and a Technical Training School at Wendover, the latter graduating 498 welders, vulcanizers, sailmakers, instrument repairmen, and the like. Air Service head-

quarters in England was commanded by Colonel C. R. Day.

Finally came the Handley-Page agreement of January 28, a monster coöperative Anglo-American night-bombing venture to turn out 30 of these fearful squadrons. The United States was to furnish the Handley-Page parts, except linen, which was to be deducted from the part of the supply allocated to her, increase the shipment of dope for the wings by 20,000 gallons monthly, provide 3,000 laborers to build the five airdromes necessary, man the three aircraft acceptance parks which were to be built by the Royal Flying Corps, provide three training depots, and pay £670,000 for construction and £50,000 weekly for assembly. The British, in addition to supplying the linen and the three parks, were to convert Lancashire cotton mills and weaving sheds into assembly shops and provide much of the labor and all the technical knowledge.

This project was held up four months by delay in production of parts in the United States. On July 25, 1918, however, the first sets sailed, and by the cessation of hostilities 10 shipments had been received overseas, of which five, sufficient for 70 planes, were at the Oldham assembly plant. On August 8 nine Handley-Page companies of 2,500 men sailed, followed on the 17th and the 31st by the First and Second Acceptance Parks of 57 officers and 600 men each, and in September by a training depot and a service squadron. The first detachment of enlisted men completed their training at the Oldham factory on October 18, ready for service, and 60 flying officers and three squadrons were under training at Ford Junction.

On November 13 there were 19,535 Air Service personnel in England and another 11,740 who had been sent on from England to France. The schedule called for 57,488 more to pass through that country to June 30, 1919. All these men were to stay for a short time, relieving the British labor shortage on the one hand, and securing further training on the other. The total American expeditures in England were estimated to be about $36,000,000, including about $12,500,000 for the Handley-Page programme, $20,000,000 for planes, hangars, and equipment, and $2,500,000 for training. The arrangement was of decided mutual advantage, and it was one of the most effective ways in which American and Allied resources were made to dovetail to the common end.

To Italy also were sent cadets for training, all of them as Caproni bombers. On July 10, 1917, Italy offered to receive 500 Americans in its schools, and on August 27 the United States accepted, subject to the condition that no expense except maintenance should attach to the training and that the men might be used anywhere desired on the west front. On September 28, 47 cadets reported at Foggia from Paris, " went into quarters," as their log says, " and started flying the same day." By October 30, 1918, 126 night bombers had graduated, with 33 more still in training and three killed in accidents, and 1,468 hours had been flown. On November 6, 49 fully trained American night bombers were with Italian squadrons in the zone of advance. The Rome headquarters of the Air Service was under command of Major Robert Glendenning.

In France, in England, in Italy, then, American

airmen were concentrating in large numbers. Overseas figures show that on November 6, five days before the armistice was signed, 77,726 men of the Air Service had actually arrived overseas. Of these, 20,003 were with the A. E. F. in the zone of advance and 32,561 in the service of supply; 4,314 were with the French in the zone of advance; 515 were with the British Expeditionary Force; 20,162 were in England; and 49 were in the Italian zone of advance and 122 in the Italian service of supply. At the termination of hostilities the Air Service in France included in the zone of advance 2,161 officers and 22,351 soldiers, a total of 24,512 at the actual front. There were also 4,643 officers and 28,353 soldiers in the service of supply. With the French armies there were detailed eight American flying officers, and with the British Expeditionary Force there were 49 officers and 525 soldiers. The total personnel in France consisted of 6,861 officers and 51,229 soldiers, a total air strength of 58,090. Air Service mechanics regiments with the French Army included 109 officers and 4,744 soldiers. Nineteen months before, it may be recalled, the total strength of the Air Service was 1,185 officers and men.

Slowly at first, but finally very rapidly, the young American airmen began to appear over the trenches in every sector from the North Sea to the Adriatic. Brigaded with French, British or Italian squadrons or organized into American squadrons, they came just at the critical time of the war. With the British they saw the beginning of the German rout in Flanders; with the French and their own troops, Château-Thierry, St. Mihiel, and the final advance to victory;

with the Italians, the abortive Austrian offensive and subsequent rout. Their part, although not decisive in the extreme degree of which early American optimism had given hope, was nevertheless important in effecting the amazingly sudden crumbling of the enemy and gave definite assurance of leading to early and decisive Allied aerial supremacy.

CHAPTER XVII

THE AIR SERVICE IN ACTION

Exploits of the Air Service at the front — First German planes brought down by American aviators — First reconnoissance over the German lines — Death of Major Raoul Lufbery — First American-trained ace — First bombing raid — A reputation established, but at a cost — The Air Service first a major striking force at Chateau-Thierry — Death of Lieutenant Quentin Roosevelt — Official recognition of the Service in the second battle of the Marne — The Air Service at St. Mihiel — Command of the air with the Americans — General Pershing's tribute — Further unofficial testimony — The offensive on the Meuse — Flights in force — Harassment of the German retreat — American aviators with the British in Flanders — Their service as reported by the Royal Flying Corps — American aviators with the Italians — The Austrian rout on the Piave — A daylight raid on the naval base at Pola — Summary of achievements of the Air Service in action — Enemy planes and balloons brought down in France — Losses of American planes and balloons — List of American aces — Air Service casualties — General Pershing's last words of praise.

On April 14, 1918, a year and a week after our declaration of war, the first two German planes fell prey to aviators in the American Air Service, Lieutenant Alan F. Winslow, later shot down and held prisoner in Germany, and Lieutenant Douglas Campbell, later America's first ace. The former's account, written privately, follows:

On Sunday morning April 14th, I was "on alert" from 6:00 a. m. 'till 10:00 a. m. with Lieut. Douglas Campbell. We were sitting in the little alert tent, playing cards, waiting for a call. Our machines were outside, ready at a moment's notice. At 8:45 I was called to the 'phone, told by the information officer, who is in direct touch with all

batteries and observation posts, that two German aeroplanes were about two thousand metres above the city, which is only a mile or so from here. We were told they were going east. We were rushed down to our machines in side cars, and in another minute were off in the air.

"Doug" started ahead of me, as I was to meet him above a certain point at five hundred meters, and then take the lead. I gave him about forty-five seconds' start, and then left myself, climbing steeply in a left-hand spiral in order to save time. I had not made a complete half turn, and was at about two hundred and fifty metres, when straight above and ahead of me in the mist of the early morning, and not more than a hundred yards away, I saw a plane coming toward me with huge black crosses on its wings and tail. I was so furious to see a Hun directly over our Aviation field that I swore out loud and violently opened fire. At the same time, to avoid my bullets, he slipped into a left-hand reversement, and came down, firing on me. I climbed, however, in a right-hand spiral, and slipped off, coming down directly behind him and "on his tail." Again I violently opened fire. I had him at a rare advantage which was due to the greater speed and maneuverability of our wonderful machines. I fired twenty to thirty rounds at him and could see my tracers entering his machine. Then, in another moment, his plane went straight down in an uncontrolled nose-dive, his engine out of commission. I followed in a straight dive, firing all the way. At about six feet above the ground he tried to regain control of his machine, but could not, and he crashed to earth. I darted down near him, made a sharp turn by the wreck, to make sure he was out of commission, then made a victorious swoop down over him, and climbed up again to see if "Doug" needed any help with the other Hun — for I had caught a glimpse of their combat out of the corner of my eye.

Mind you, the fight took place only three hundred metres up, in full view of all on the ground and in the near-by town, and directly above our Aviation field. Furthermore, mine dropped about one hundred yards to the right, and

"Doug's" one hundred yards to the left of our field. These are remarkable facts, for one of our Majors, who, with the French army since 1915, has shot down seventeen machines, never had one land in France — and here we go, right off the bat and stage a fight over our aerodrome and bring down two Huns right on it. It was an opportunity of a lifetime — a great chance.

When we landed, only our respective mechanics were left in the drome to help us out of our flying clothes. The whole camp was pouring out, flying by on foot, bicycles, side cars, automobiles; soldiers, women, children, majors, colonels, French and American — all poured out of the city. In ten minutes several thousand people must have gathered. "Doug" and I congratulated each other, and my mechanic, no longer military, jumping up and down, waving his hat, pounded me on the back instead of saluting and yelled: "Damn it! That's the stuff, old kid!" Then Campbell and I rushed to our respective Hun wrecks.

On the way there — it was only half a mile, I ran into a huge crowd of soldiers — blue and khaki — pressing about one man. I pushed my way through the crowd, and heard somebody triumphantly say to the surrounded man in French: "There he is; now you will believe he is an American." I looked at the man — a scrawny, poorly clad, little devil, dressed in a rotten German uniform. It was the Hun pilot of the machine I had shot down. Needless to say, I felt rather haughty to come face to face with my victim, now a prisoner, but did not know what to say. It seems he would not believe that an American officer had brought him down. He looked me all over, and then asked me in good French if I was an American. When I answered, "Yes" he had no more to say. . . .

"Doug" had set his Hun machine on fire at three hundred metres, and it had fallen in flames, rolling over three times, and then completely burning up. There remained but a charred wreckage, like the sacrifice of some huge animal. The Hun pilot had been thrown out and was badly off. His face, hands, feet, nostrils and lungs were all burnt, while his leg was broken. He is now in hospital and my

Boche is probably commencing his job of ditch digging for the rest of the war.

They got much valuable information from my man — the other couldn't speak. He was a Pole, said he was not an officer because he was a Pole, although he had been an "aspirant" and a pilot at the front for two years. He said to me, with a sort of sigh of relief, throwing up his hands at the same time, "*Alors, la guerre est fini pour moi!*"

That afternoon my wrecked Hun plane and the charred result of "Doug's" good work were exhibited in the public square of the town, surrounded by an armed guard, and overlooked by a French military band. It also was a great day for the townspeople, and has had a good moral effect. You can imagine it, when you realize it took place above their roof tops, at only three hundred meters, and that they were able to see the whole fight. . . .

An amusing incident was this, the fight was so near to the earth that bullets were flying dangerously all about the ground. No one was hurt, save a French worker in the field, who received a hole through his ear from one of my bullets, and is very proud of it.

On April 14 American pursuit units began operating on the Toul sector. On the next day Major Ralph Royce made the first American reconnaissance over the enemy's lines, for which he was later decorated with the French *Croix de Guerre*.

On May 15 a delightful tableau was staged at the front. While a large and formal assemblage was waiting for a French general to come to confer decorations, the communiqué says,

Captain Peterson made an ascent and encountered two German planes and shot down both within one minute, firing 60 shots at first and 15 at second. First plane burst to flames before hitting ground and wings of second were seen to crumble up when nearing earth. No definite information of third hostile plane reported brought down.

Later it was added:

The planes were sighted by Captain Peterson flying at 4,000 metres in single file towards our line. Captain Peterson swung in behind them at 5,200 metres and attacked the rear plane firing 50 rounds. The hostile plane dove vertically 500 metres and broke into flames and fell. Captain Peterson was meanwhile attacked by the second plane from the front. He again attacked from above, firing 75 rounds. The hostile plane threw out a cloud of smoke and attempted a sharp turn but slipped. The wings folded up and one fell off as the plane fell. After the hostile planes were brought down, the ceremony proceeded.

On May 19 an irreparable loss to American aviation was reported. Major Raoul Lufbery, American "ace of aces," credited with 18 enemy planes in the magnificent fighting he had done as a member of the Lafayette Escadrille, was officially reported to have been "seen to fall from his machine, which itself fell a short distance from him. He was possibly wounded or dead before he fell. Earlier reports stated that he was at the time engaged in a long running fight and was flying upside down at a height of 2,000 feet." A more detailed account was given in the press:

At about 10 o'clock Sunday morning a German triplane suddenly descended from the clouds, apparently because of engine trouble, until it was some 1,500 metres over the city of Toul. Lufbery in his Nieuport combat plane gave chase, followed by two American machines. The enemy made for his own lines, and when eight miles away, Lufbery was seen to attack from under the tail, but then he drew off as if his machine gun had jammed. Two minutes later he attacked again from the same position and almost immediately his machine burst into flames. Those on the ground suddenly saw his form jump from the machine. Lufbery's body fell some 400 yards from his machine.

Major Lufbery was known throughout the American army and in the French air service as "Luff," and was one of the most daring fliers on the front. Lufbery had just returned from leave several days before his time was up, believing that he was needed in combatting the German effort at aerial supremacy. He has been awarded the *Croix de Guerre*, the British Military Cross, the French *Medaille Militaire* and the Legion of Honor.

It was Lufbery's ambition to die fighting. He was popular not only because of his exploits in the air, but for his colorful, picturesque personality and career. Lufbery was an American by paternal citizenship, a Frenchman by birth and devotion, being born in Clermont, France, thirty-four years ago.

Shortly after, as if in some degree to compensate, came the first American-trained ace. On May 31, Lieutenant Douglas Campbell, who had been graduated from the University of California ground school and received his final training in France, brought down his fifth plane near Pont-à-Mousson. Campbell sighted his enemy at 4,500 metres, got on his tail when he tried to escape to his own lines, and signalled him to surrender, as the German's ammunition had run out. The German declined and, as Campbell said, "I did not like the idea of shooting him down when he was not fighting but I could not let him get away."

A little later, on June 12, the first raid by an American bombing squadron was carried out against Dommary-Baroncourt, northwest of Metz. General Pershing reported that it was executed by five planes, which dropped 80 bombs, one striking a warehouse at the station. A correspondent describes the flight as follows:

As they made their start for Germany, the bombing planes received quite an ovation. A number of French and

British aviators and officers and a large number of American fliers cheered them from the flying field as they came racing down the grass, tilted upward and then turned north toward the enemy's lines.

The German anti-aircraft batteries gave them a hot reception as they crossed the front, but this shelling was extremely tame compared to what they underwent as they approached Dommary-Baroncourt. Two of the American planes leading the squadron became the particular targets of the anti-aircraft guns. They twisted and dived under a heavy shrapnel fire until they arrived over their objective — a railway junction and the surrounding buildings three miles below.

The commanding officer of the unit was in the leading plane as observer and it sped over the objective first, the commander releasing his bombs. At the same time he signaled to the other machines which followed in a nearby straight line. Bursting bombs laid a perfect circle of smoke about the railway junction. The smoke obscured the buildings as the bombers turned southward toward the American lines.

German attacking planes met the Americans two miles from Dommary and attempted to pick off those planes which were trailing, but the lively fire of the other machines forced the enemy to give up the attempt just as the line was reached. Arriving at the starting point, the aviators were showered with congratulations on the results of the first raid by their envious comrades.

By June the young American flying force had made a reputation for itself. From April 14 to June 1 pursuit pilots over the Toul sector were credited by the French with 17 enemy airplanes brought down and another 15 unconfirmed. A price, however, had been paid. On July 2, for example, General Pershing reported: "American aviation squadrons coöperated with our troops in the action northwest of Château-Thierry. Three of our aviators did not return."

Bombing work especially was costly. On July 11 General Pershing reported: "As a result of a bombing expedition last evening, five of our machines are missing." These were of a squadron of 21 which in a raid on Conflans were overtaken by a heavy wind which exhausted the gasoline capacity of five of the planes. The Germans, in their official announcement, made the most possible of this loss.

Fitting it was that Château-Thierry should mark the coming of the American Air Service into its own as a major striking force at the same time and place that the American Army as a whole proved itself the equal of any in the world. Previously there had been innumerable individual exploits by our aviators and much vital work accomplished, but if one must choose a date when the American Air Service as a Service received its baptism of battle, it may well be in that climax of crises when, again at the Marne, the mighty German machine had spent its last effort and the Allies were gathering themselves for the blow that was to eventuate in the complete military defeat of their foe.

Daily during those critical hours the press carried detailed reports of American aerial exploits while the official reports maintained a vexing silence. On July 2 a squadron of nine American planes was described in a thrilling half-hour fight over Château-Thierry with 13 German planes, of which six were thought brought down. The next day four more Germans were reported brought down, while the German official communiqué claimed four American victims of a squadron of nine. The first of these early battles was unofficially described as follows:

WITH THE AMERICAN ARMY ON THE MARNE, July 3.— American aviators met the Kaiser's best fighting airmen in a sensational encounter near Château-Thierry late yesterday. Six German planes were brought down. We had no losses. This is the largest air fight in which members of the American air squadron have taken part.

Their opponents were a unit of the famous Richthofen's own squadron, the leader of which was killed some weeks ago, but which has retained his name. The squadron was first formed by the renowned Boelke. It has been many times honored by the Kaiser, and is the only German squadron in which each flyer has individual insignia on his avion. It is known by the red nose and red tail of its avions. The reputation of this squadron is that it is the hardest fighting of all the German fliers.

It was just before 7 o'clock when the American air field got word that a fleet of Boche aviators was coming after two of our observation machines over the German lines near Epaux. In a few moments nine of our planes, led by Lieutenant Kenneth L. Parker, were in the air, bound north. As they neared our line they saw 13 Germans flying in a new double-deck formation, nine about 5,000 metres and four about 2,000 metres up. This formation is adopted by the Germans so that when either group is attacked the other, perhaps unseen, may come upon the opponents with overwhelming force.

When our aviators saw this formation five of our nine machines immediately mounted and four descended, so that we had the same formation. The German top deck was over ours, but our bottom deck was over the Germans. About 7:20 our lower group engaged the German lower group, when two Germans were brought down and the other two made away.

Three minutes later the two upper groups were in combat about four kilometres north of Château-Thierry in an aerial battle which lasted an unusually long time — 35 minutes — at the end of which four more Germans had been brought down.

In the fight Lieutenant Cleveland W. McDermott got cut

off by the remaining Boche, after bringing down one. He was forced to flee 30 kilometres back of the Hun lines, until he escaped by evolutions and flew back toward the American lines, coming down out of gasoline just back of our positions.

Credit for bringing down the German airplanes goes to Lieutenants Ralph A. O'Neill, of Nogales, Ariz.; John H. Stevens, of Albion, N. Y.; Kenneth L. Parker, of Dowagiac, Mich.; Tyler C. Bronson, of New York City; Maxwell O. Perry, of Indianapolis, Ind.; Cleveland W. McDermott, of Syracuse, New York.

The American airmen now have a sector of thirteen kilometres on this front, their work extending on both sides of the present American sector.

So each day the activity increased. American fliers were both brave and venturesome beyond praise. Not only were they in constant battle, but they went off on long-distance reconnaissances, as when on July 10 they penetrated German-occupied territory for a distance of 50 miles north of Château-Thierry, and on long-distance bombing raids, as when a squadron of 21 planes set out for Coblenz, six of which the Germans claimed to have shot down. Weaknesses, of course, were discovered, especially in bad coördination between the Air Service and the Artillery, but by and large the work done in these critical hours by an organization almost new to battle was most gratifying.

One spectacular loss was suffered, that of Lieutenant Quentin Roosevelt, son of the former President of the United States, whose death at the point of extreme danger, occurring moreover on Bastile Day and only a few days after he was reported to have brought down his first German, touched the world's imagination as almost no other individual occurrence could have done.

Let his enemy describe it through the Wolff Bureau announcement:

On Sunday, July 14, an American squadron of twelve battleplanes was trying to break through the German defense over the Marne. In the violent combat which ensued with seven German machines one American aviator stubbornly made repeated attacks. This culminated in a duel between him and a German non-commissioned officer, who, after a short fight, succeeded in getting good aim at his brave but inexperienced opponent, whose machine fell after a few shots near the village of Chambry, ten kilometres north of the Marne.

His pocket case showed him to be Lieutenant Quentin Roosevelt, of the aviation section of the United States Army. The personal belongings of the fallen airman are being carefully kept, with a view to sending them later to his relatives. The earthly remains of the brave young airman were buried with military honors by German airmen near Chambry at the spot where he fell.

To Lieutenant Roosevelt the *Stars and Stripes*, the official paper of the A. E. F., gave the honor of being the first American lost in the battle of the Champagne. The paper's summary of the general situation says:

The new German offensive gave the American aviation forces their first opportunity to participate in major operations. Allied airplanes in force had crossed the German lines at daylight Sunday morning to clear the air, harass the enemy's movements, and learn as much as possible about the German concentrations and artillery positions.

There was no pretense of secrecy. The Allies knew the Germans were on the eve of attacking, and the Germans knew that the Allies knew.

In these air forces the Americans were well and gallantly represented. Their observation airplanes had done a share of the preceding day's photographing, locating troops and guns. As a testimony of their success it may be said that

during Sunday they located twenty-five enemy batteries, most of which were neutralized by our artillery before they were fairly in action.

Our chaser squadrons were instructed to cease air fighting and fly low to harass the enemy's troops and ammunition movements with machine gun fire. It was in this preliminary fighting that Quentin Roosevelt, who, three days previously, had brought down his first German, was lost.

His loss was quickly avenged. The American aviators believe they destroyed fourteen machines on Sunday, Monday and Tuesday. Some of these are officially confirmed. Others were too far within the German lines. For instance, an American squadron patrolling over the German lines met a patrol of equal number and brought down four of the enemy.

It was on Monday and Tuesday, when the Germans were forced to abandon moving troops and munitions by night, that the Allied aviators did their most spectacular work. A great flock of more than 200 went out Monday, the Americans flying the lowest, the French next, and the British the highest. When they reached an important highway the American commander dived. Every American followed, then the French, and then the British.

Every machine emptied its guns into the miles of wagons and the fields to which the Germans scuttled.

"An ant hill would look like a Sunday school compared to that bunch," said one of the aviators. "There is no telling how many we hit, but it will be a long time before those trucks will haul soldiers again."

Time and time again the Americans returned for ammunition. Some of them made five flights in a single day.

The early work of the Service was much appreciated by the general officers. On August 1 the Chief of Staff of the First Army Corps wrote his Chief of Air Service:

1. The Corps Commander is extremely gratified and pleased with the effective, splendid work of the observation squadrons of this Corps.

2. In spite of control of the air by the enemy, the pilots and observers have been tireless and successful in carrying out their missions of observation and for the purpose of taking photographs which have played a great part in the successful advance of the Corps.

3. The Corps Commander desires that you convey his personal thanks to those under your command, and he further desires that the names of those whom you deem worthy of special recognition be reported promptly to these Headquarters for transmission to the Commander-in-Chief.

Likewise Major-General C. R. Edwards of the 26th Division sent a special letter on July 31 to the commander of the 12th Aero Squadron:

1. In the memorable attack and campaign of the second battle of the Marne, in which my division, the 26th, participated from the 18th to the 25th of July, inclusive, I relied much upon the effective and gallant service of your squadron.

2. As far as material would warrant and allow, your personnel rendered gallant and efficient service. The interest and spirit was splendid.

3. On the behalf of the division, let me express my thanks and congratulations. You have a fine body of young men. Tell them that we like them and believe in them.

The start made at Château-Thierry developed rapidly. Aviators in increasing numbers went out to the front. America's aerial strength constantly mounted to justify the undercurrent of fear that was beginning to be expressed in Germany and especially in the Rhineland. In the first two weeks of August, for instance, 964 flights were reported, with 94 combats, 20 enemy airplanes brought down, and 5,300 kilograms of bombs dropped. One pursuit squadron in July alone was credited with 28 enemy

AIRPLANE PHOTOGRAPH OF CHATEAU-THIERRY BEFORE IT WAS RETAKEN BY THE AMERICANS AND THE FRENCH

They have brought down (in the last two days) 12 balloons and more than 60 enemy planes, while less than a third of that number of our planes are missing. In conjunction with French and British aviators, they have, notwithstanding unfavorable weather, rendered valuable service and successfully executed many missions.

On October 1 General Pershing reported: "Since September 26 our aviators have shot down more than 100 hostile planes and 21 balloons."

The work at St. Mihiel was highly praised by General Pershing. On September 16 he sent the following letter to the Chief of Air Service of the First Army:

Please accept my sincere congratulations on the successful and very important part taken by the Air forces under your command in the first offensive of the First American Army. The organization and control of the tremendous concentration of Air forces, including American, French, British and Italian units, which has enabled the Air Service of the First Army to carry out so successfully its dangerous and important mission, is as fine a tribute to you personally as is the courage and nerve shown by your officers a signal proof of the high morale which permeates the service under your command.

Please convey to your command my heartfelt appreciation of their work. I am proud of you all.

The unofficial reports from France chronicled these achievements more fully. On September 20 the Associated Press, which on February 27 had carried the sensational report that "control of the air over the American sector belongs to the enemy," and that "German planes come and go over the American lines almost at will," stated that American aviators were now "undisputed masters of the air" in the Verdun region. The *New York Times* correspondent quoted

the French as saying that the two American offensives at St. Mihiel and west of Verdun "were the best prepared and provided for in aviation of any battles yet fought in the war." Reuter's on September 30 said: "The outstanding achievement of the American Army in the offensive is undoubtedly due to its aviators, who have done all that was expected of them and much more."

Again, on October 19, General Pershing reported:

> Yesterday our pursuit squadrons on the front of the First Army were engaged in 25 combats in which 17 enemy machines were brought down. Our bombing units dropped 4½ tons of bombs on Buszancy, Bayonville and Remonville.

On the 23rd the official statement read:

> Our pursuit squadrons shot down 15 enemy airplanes and 1 observation balloon. Three of our observation balloons were destroyed and 6 of our machines are missing. Our bombing units dropped 5 tons of bombs on enemy concentration points.

On October 27, 13 enemy planes were destroyed with the loss of five American planes, and 3½ tons of explosives dropped. Three more enemy planes and one balloon were destroyed on the 28th without loss; 18 planes on the 29th, with the loss of five American planes; and 21 planes and two balloons on the 30th, with the loss of two American planes. On October 31 six tons of bombs were reported dropped on Barricourt, Bayonville and Longuyon, and on the next day three tons on the roads and dumps near Tailly, Barricourt and Villers-devant-Dun; also seven enemy planes were brought down without loss and enemy troops and convoys machine gunned.

For the next to the last week before the signing of the armistice, the most spectacular effort yet made by the American Air Service was chronicled in the following tantalizingly brief words of the Coördination Section report for the week of October 30, received in Washington shortly after:

> In spite of the rainiest week of the year, operations of American squadrons at the front during the past week have been the most satisfactory so far, according to direct report by telephone from the zone of advance. All missions were successfully carried out. A perfect battle formation of 190 planes attacked on the largest scale ever attempted by our air forces, with highly satisfactory results.

Another monster flight of 45 day bombers and 100 pursuit planes was reported on November 4, just a week before the signing of the armistice, as follows:

> In the course of the day, improving weather conditions permitted our planes to carry out very successfully their missions of reconnaissance and infantry liaison. A raid with a force consisting of 45 day-bombardment and 100 pursuit planes was made against Montmedy and obtained excellent results on the crowded enemy traffic at that place. Over five tons of bombs were dropped. Determined attacks by enemy pursuit planes gave us added opportunities to destroy his airplanes. During the day's fighting 30 enemy planes were destroyed or driven down out of control and three balloons were burned. Seven of our planes are missing.

The rapid retreat of the Germans before their final collapse brought no let up in this activity. On November 5 two tons of bombs were dropped by a flight of 30 planes on Meuse and Rochcourt; enemy infantry was machine gunned, and 20 enemy planes and two balloons brought down, with the loss of seven American planes. On the 6th seven more enemy planes and

two American planes were destroyed, and a ton of explosives dropped on roads by which the enemy was attempting to escape. On the 8th three enemy planes and four balloons were shot down, with one American plane missing, in a continued pursuit and harassment of the fleeing Germans.

During all this time other American fliers brigaded with British squadrons in Flanders were making an equally enviable record. These men were early graduates of the American ground schools sent over to British schools while American flying fields were making ready to take the large number of cadets waiting training, and they had been given every facility that British experience and equipment offered. Beginning in July the Royal Flying Corps communiqués contain mention after mention of enemy planes brought down or gallant work performed by American fliers. This little handful of Americans, only about 200 fliers in all, driven on by the incentive of their presence with a foreign force, took every chance of danger offered, as was shown in their final casualties of 44 per cent. dead, wounded, missing, or otherwise out of action.

In the period from July 1 to August 25 the British reported these Americans to have brought down 50 enemy planes and seven balloons; from August 25 to September 8, 14 planes and three balloons; from September 9 to September 22, 11 planes and one balloon; and from September 22 to within three weeks of the end of the war, 25 more enemy planes, making a total of well over 100 for these men alone. Over 30 different men were mentioned by name in the first compilation, over a dozen were decorated with the Distinguished Flying Cross, and one, Lieutenant A. F.

Bonnalie, was given the British Distinguished Service Order for "a marvelous performance" described as follows:

Lieutenant A. F. Bonnalie, an American attached to the Royal Air Force, has been awarded the British Distinguished Service Order. On August thirteen, this officer led two other machines on a long photographic reconnaissance. In spite of the presence of numerous enemy aircraft they were able to take all the photographs required, but were attacked by six Fokker biplanes.

During the combat Lieutenant Bonnalie saw that one of his accompanying machines was in difficulty and that an enemy airplane was nearly on its tail. He at once broke off combat with the enemy with whom he was engaged and dived to the assistance of the machine in trouble. He drove off the enemy plane, regardless of the bullets which were ripping up his own machine.

Eventually, however, his tail planes and his elevator wires were shot away and his machine began to fall in side dash slips. Lieutenant Bonnalie managed to keep his machine facing toward the British line by means of the rudder control, while his observer and the third machine drove off the enemy aircraft which was still attacking.

In its damaged condition Lieutenant Bonnalie's machine was tail heavy and he therefore had his observer leave his cock-pit and lie out along the cowl in front of the pilot. In this manner he recrossed the British trenches at a low altitude and righted his machine sufficiently to avoid a fatal crash.

Had it not been for the gallantry of Lieutenant Bonnalie, the injured machine to whose assistance he went would have fallen into enemy territory, as pilot had been wounded and its observer killed. Lieutenant Bonnalie's own machine was riddled with bullets, and it was a marvelous performance to bring it safely to the ground.

Two American squadrons, the 17th and 148th, also were attached to the British. An idea of the work

they did may be had from the following citation in a R. F. C. communiqué:

A raid was carried out by —— American Squadron on —— aerodrome, in conjunction with squadrons of the 5th Group. After the first two squadrons had dropped their bombs from a low height, machines of —— American Squadron dived to within 200 feet of the ground and released their bombs, then proceeded to shoot at hangars and huts on the aerodrome, and a chateau on the northeast corner of the aerodrome was also attacked with machine-gun fire. The following damage was observed to be caused by this combined operation. A dump of petrol and oil was set on fire, which appeared to set fire to an ammunition dump; six Fokker biplanes were set on fire on the ground, and two destroyed by direct hits from bombs; one large Gotha hangar was set on fire and another one half demolished; a living hut was set on fire and several hangars were seen to be smouldering as the result of phosphorous bombs having fallen on them. In spite of most of the machines taking part being hit at one time or another, all returned safely, favorable ground targets being attacked on the way home; —— Squadrons bombed the aerodrome after the low-flying attack was over, and demolished the chateau previously referred to.

The work these squadrons did was appreciated by their Allies. In September the commander of a British squadron which the Americans had been escorting in its bombing raids wrote: "I do not consider that any squadron in France is supplied with a better escort than is my squadron." That was very strong praise indeed and well compensated the lone, arduous, and extremely dangerous work involved.

Meanwhile, the handful of men who had been sent in October, 1917, to Foggia, Italy, for training as Caproni bombing pilots were also taking their places on the front. They arrived in June, 1918, just at the

moment when a new Austrian offensive was threatening Italian safety, and undoubtedly had considerable value in stimulating a shaken morale, as well as having the opportunity to participate in the first daylight raid on the Austrian naval base at Pola on July 17. Their experiences are related by Lieutenant Willis S. Fitch as follows:

After about eight months I was finally able to shake off the cobwebs of Foggia, and get to the front here a little over a month ago. I came up with a few others to fly in Italy squadrons until we got our own planes. We were given a great send-off in Rome, as we were the first Americans of any branch of the service to go into action on the Italian front. We arrived at our station on the 19th of June, just as the Austrian offensive was in full force, and, much to our joy, were put into action at once without further training. In fact, we went over the lines on a bombardment the following day. We were busy all through the offensive, which soon turned into a defensive or rout for the Austrians. An objective assigned to us one night for bombing the following morning would have to be changed because during the night the Italian infantry had advanced and already taken that position. Each day our trips were longer, as the Italian line moved forward. The Austrian Air Force suffered tremendous losses, over 100 planes being destroyed in the first few days.

The efficiency of their anti-aircraft guns was not damaged, however, and seldom did we come back from over the lines without bullet or shrapnel holes in our planes. One of our boys was brought down on his first trip over the lines, or at least he came down within their lines. It was very cloudy that day and rainy. We were flying at about 1,000 metres and under, which is extraordinarily low for day work in these large machines. Another boy was hit squarely by a shell which carried away one of his engine controls and one of his elevator controls. He just did make the home "piste," scraped a hangar and smashed up in

landing. On the same day another man had a Boche on his tail which he brought down after a lively scrap, but his plane had 163 bullet holes in it.

I have been very lucky myself. The day before yesterday, for example, I made a trip over the lines with another Caproni, to drop some propaganda. We had four or five chasse planes for an escort to take care of the enemy while we were doing our work. We crossed the Piave at about 300 metres, and the minute we were over, we were greeted warmly by a burst of shrapnel just over our heads. That was the signal for the fun to begin. From then on we weren't left alone for a minute. Bang! and a big black puff would appear just off our left wing. I would kick in all my right rudder and wind the wheel over, and off we would go at right angles to our previous course. Bang! and another black puff would appear in front of us. This time they had our altitude. Down we shot with full motors for a couple of hundred metres and then up on a turn. Right in the middle of it an explosion came, seemingly right under our feet, and the machine jumped from the force of it. I felt a blow in the arm and glanced around to see where the shot had hit. There was no hole that I could see and the motors still pounded along beautifully, so we kept on for 10 or 15 miles more until we were over the objective. Then, with the "manifistini," as they call propaganda, gone, we turned back and I picqued her nose down to run the gauntlet with all possible speed. Sometimes climbing, sometimes diving, and always wallowing around in a zig-zag course like a ship in a heavy sea, we reached the Piave. Never before did the house tops of Venice look so good. Once in our lines, I turned the wheel over to the other pilot and examined my arm. The sleeve of my flying combination was completely torn away, as was also my uniform coat underneath. But my arm was only scratched a little and I could scarcely feel the wound. I picked a piece of shrapnel out of the sleeve that was about two inches long — big enough to do quite a bit of damage if it had hit squarely. When we had landed, an examination of the plane showed five shell holes in it. I found an-

other small piece of shrapnel in my foot that had spent its force and hadn't penetrated my leather boot. The Archies are very accurate on the Piave but they were unusually so that morning.

But, yesterday we staged a "regular party." A daylight raid on Pola, the big Austrian naval base in the Adriatic, had been talked about for several months but had been always considered too fraught with danger. They had bombed it many times with success at night, but they wanted such accuracy as only daylight can give. So after a week's preparation, it was staged yesterday. They didn't want to take any Americans at first because of our inexperience, but after a great deal of urging, I finally got aboard with one or two others. We started at daybreak and it was broad daylight when we reached the coast. It was a wonderful sight to see the big sturdy Capronis with their loads of bombs and passengers, and above them the little chasse planes darting in and out in search of the enemy. Over sixty planes took part, Capronis, lighter bombing planes, chasse planes, and hydro-airplanes. Down on the water there were two fleets of destroyers attacking in coöperation with us. It was a 110-kilometre flight straight across the Adriatic and even at that height we were out of sight of land for quite a while. We all had on life belts for use in case of a forced landing at sea. But all went well. We went over the objective one by one and dropped our bombs without being molested. We were fired at by land batteries and by a dozen large battleships in the harbor but their range was poor. When I turned away, I could see bursts of fire on the center of the city, on the arsenal and one on a torpedo boat in the harbor. The photographs taken showed very favorable results. It was a long trip home and we were all pretty tired, but happy over the results and to know that all of our machines returned. And so the first daylight raid on Pola has come and gone.

Final figures giving with exactitude what the American Air Service accomplished in its different sectors will not be available until all the overseas records have

been brought together, checked, and summarized. Over 1,000 fliers, however, were actually in action with the A. E. F. alone, including, as of October 30, 291 pursuit, 309 observer, and 62 bombing pilots, and 288 reconnaissance and 70 bombing observers, with a record for that week of 63 enemy planes brought down, and seven Americans killed, 12 missing, and 13 wounded. To November 11 official figures reported by General Harbord under date of December 15 give the number of enemy planes brought down by American fliers as 491 confirmed and 354 unconfirmed, a total of 845; the number of enemy balloons reported destroyed was 82, of which 57 were confirmed. During the activities of the Air Service in France it lost 271 planes and 45 balloons. With a total Allied strength of but 5,500 planes and a total enemy strength of 3,300 planes, it is evident that the toll taken by the Americans formed a large part in the replacement programme upon which the Germans had to figure. Despite the delays and disappointments, it is evident also that the American Air Service took a far bigger part in the hostilities than was commonly supposed.

Most of the German planes the destruction of which was confirmed, a total of 462, fell to the 63 American aviators who by bringing down at least five enemy planes won the coveted designation of "ace." The official list of American aces of January, 1919, with the number of victories credited to each, is as follows:

Captain Edward V. Rickenbacher, Columbus, Ohio......26
First Lieutenant Frank Luke, Jr., Phoenix, Arizona (killed in action September 30, 1918)..............18
Major Victor Raoul Lufbery, Wallingford, Connecticut (killed in action May 19, 1918)..................17

Captain Reed G. Landis, Chicago, Illinois..............12
First Lieutenant David E. Putnam, Brookline, Massachusetts (killed in action September 14, 1918).........12
First Lieutenant Fielde Kindley, Gravette, Arkansas....10
First Lieutenant Jacques Michael Swaab, Philadelphia, Pennsylvania..................................10
First Lieutenant George A. Vaughn, Brooklyn, New York..10
Captain Elliott W. Springs, Lancaster, Pennsylvania.... 9
First Lieutenant Thomas G. Cassady, Spencer, Indiana.. 9
First Lieutenant William P. Erwin, Chicago, Illinois.... 9
First Lieutenant Chester E. Wright, Cambridge, Massachusetts... 9
Major James A. Meissner, Brooklyn, New York......... 8
Captain Hamilton Coolidge, Boston, Massachusetts (killed in action October 27, 1918)................ 8
Captain G. Defreest Larner, Washington, D. C.......... 8
First Lieutenant Paul F. Baer, Fort Wayne, Indiana.... 8
First Lieutenant Henry Clay, Jr., Fort Worth, Texas... 8
First Lieutenant Frank O. D. Hunter, Savannah, Georgia. 8
First Lieutenant Wilbert Wallace White, New York, New York (died December 13, 1918).................. 8
Second Lieutenant Clinton Jones, San Francisco, California.. 8
Captain Reid M. Chambers, Memphis, Tennessee........ 7
First Lieutenant Harvey W. Cook, Toledo Ohio......... 7
First Lieutenant Lloyd A. Hamilton, Burlington, Vermont (killed in action August 26, 1918)................. 7
First Lieutenant Lansing C. Holden, New York, New York.. 7
First Lieutenant Wendel A. Robertson, Fort Smith, Arkansas....................................... 7
First Lieutenant Leslie J. Rummel, Newark, New Jersey. 7
First Lieutenant Karl J. Schoen, Indianapolis, Indiana (killed in action October 30, 1918)................ 7
Major Harold E. Hartney, Saskatoon, Canada.......... 6
Captain Douglas Campbell, Mount Hamilton, California. 6
Captain Edgar Gardner Tobin, San Antonio, Texas...... 6
Captain Jerry Cox Vasconcelles, Denver, Colorado...... 6

First Lieutenant James D. Beane, Concord, Massachusetts. 6
First Lieutenant Clayton L. Bissel, Kane, Pennsylvania.. 6
First Lieutenant Arthur R. Brooks, Framingham, Massachusetts 6
First Lieutenant Jesse O. Creech, Washington, D. C..... 6
First Lieutenant Edward P. Curtis, Rochester, New York. 6
First Lieutenant Murray K. Gutherie, Mobile, Alabama.. 6
First Lieutenant Donald Hudson, Kansas City, Missouri. 6
First Lieutenant Robert O. Lindsay, Madison, North Carolina 6
First Lieutenant Ralph A. O'Neill, Nogales, Arizona (reported killed in accident)........................ 6
First Lieutenant Sumner Sewall, Bath, Maine.......... 6
First Lieutenant Martinus Stenseth, Twin Valley, Minnesota 6
First Lieutenant William H. Stovall, Stovall, Mississippi. 6
Second Lieutenant Howard Burdick, Brooklyn, New York. 6
Second Lieutenant Frank K. Hays, Chicago, Illinois..... 6
Lieutenant-Colonel William Thaw, Pittsburgh, Pennsylvania 5
Major Charles J. Biddle, Philadelphia, Pennsylvania..... 5
Major David McK. Peterson, Honesdale, Pennsylvania... 5
Captain H. R. Buckley, Agawan, Massachusetts......... 5
First Lieutenant Byrne E. Baucom, Milford, Texas...... 5
First Lieutenant Arthur E. Easterbrook, Fort Flagler, Washington 5
First Lieutenant George W. Furlow, Rochester, Minnesota 5
First Lieutenant Harold H. George, Niagara Falls, New York 5
First Lieutenant Edward M. Haight, Astoria, New York. 5
First Lieutenant James A. Healey, Jersey City, New Jersey 5
First Lieutenant Howard C. Knotts, Carlinville, Illinois.. 5
First Lieutenant James Knowles, Cambridge, Massachusetts 5
First Lieutenant Innes Potter........................ 5
First Lieutenant John J. Seerley, Chicago, Illinois...... 5
First Lieutenant Francis M. Symonds, New York City.. 5

First Lieutenant Joseph Fritz Wehner, Everett, Massachusetts (killed in action September 20, 1918)	5
Second Lieutenant Harold McArthur	5
Second Lieutenant J. Sidney Owens, Baltimore, Maryland	5

These successes of course, were not without their cost. A high price indeed was paid, made all the higher, it is generally agreed, by the impetuosity of the American fliers. Seven of the 63 aces were killed in action before the armistice was signed. Up to November 14 the Air Service casualties totaled 1,233, including 164 killed in action or died of wounds, 319 killed in accidents, 335 died of other causes, 200 missing in action, 102 prisoners, and 113 wounded. Of these total casualties, those of the commissioned personnel in France, as reported by General Harbord, numbered 442, including 109 killed, 103 wounded, 200 missing, 27 prisoners, and three interned. The total number of aviators killed in action on all fronts is separately reported as 150. This record portrays a burning baptism of fire for the new American service in its first months on the front.

To praise those young men who went forth into this hazardous service, to try to picture in words the heroism and sacrifice of their deeds, would be superfluous. All the world knows the romance and the risks of aerial warfare. Let the final word, then, be said by General Pershing, their Commander-in-Chief, who immediately after the armistice, in his general report to Secretary Baker, wrote:

> Our aviators have no equals in daring or fighting ability and have left a record of courageous deeds that will ever remain a brilliant page in the annals of our Army.

APPENDICES

I. The Aviation Act of July 24, 1917

An Act To authorize the President to increase temporarily the Signal Corps of the Army and to purchase, manufacture, maintain, repair, and operate airships, and to make appropriations therefor, and for other purposes.

Be it enacted, etc., That for and during the existing emergency, the President be, and is hereby, authorized to increase the present authorized commissioned and enlisted strength of the Signal Corps of the Army, including the Aviation Section thereof.

Sec. 2. That to provide the additional commissioned personnel required by this Act the President is authorized to promote, appoint, detail, or attach as temporary officers in the Signal Corps, including the Aviation Section thereof, officers of the Regular Army, National Army, or National Guard, or the Officers' Reserve Corps, or to appoint temporarily enlisted men of the Regular Army, enlisted men of the Enlisted Reserve Corps, or persons from civil life: *Provided,* That no person shall be so promoted, appointed, detailed, or attached until he shall have been found physically, mentally, and morally qualified under regulations prescribed by the Secretary of War: *Provided further,* That officers with rank not above colonel shall be appointed and commissioned by the President alone, irrespective of the rank or grade held by them on the date of the passage of this Act, and that officers above the grade of colonel shall be appointed by the President, by and with the advice and consent of the Senate, irrespective of the rank or grade held by them on the date of the passage of this Act.

Sec. 3. That to provide the additional enlisted men required by this Act, the President is authorized to raise and maintain, by voluntary enlistment or by draft, such number of enlisted men as he may deem necessary and to embody them into organizations hereinafter provided for in

section four: *Provided,* That the draft herein provided for shall not apply to any person under the age of twenty-one years or to any person above the age of thirty-one years: *Provided further,* That the grades of chauffeur, first class, and chauffeur are hereby created in the Signal Corps. The pay and allowances of a chauffeur, first class, shall be the same as a sergeant, first class, in the Signal Corps. Pay and allowances of a chauffeur shall be the same as a sergeant in the Signal Corps. All chauffeurs while serving as such shall rank with corporals of the Signal Corps and shall be subject to promotion and reduction to any other grade now authorized in the Signal Corps.

SEC. 4. That the President is hereby authorized to appropriately officer and organize the personnel of the Signal Corps into such number of divisions, brigades, regiments, wings, squadrons, battalions, companies, and flights as may be necessary, and to increase or decrease the number of organizations prescribed for the divisions, brigades, regiments, wings, squadrons, battalions, companies, and flights, and to prescribe such new and different organizations and personnel for divisions, brigades, regiments, wings, squadrons, battalions, companies, and flights as the efficiency of the service may require.

The President is further authorized to organize such headquarters and headquarters detachments for divisions, brigades, regiments, wings, squadrons, battalions, companies, and flights as may be necessary, and to prescribe new and different organizations for such headquarters and headquarters detachments whenever the efficiency of the service may require.

SEC. 5. That the President, by and with the advice and consent of the Senate, is authorized to appoint for the period of the existing emergency such general officers of appropriate grades as may be necessary for staff duty and for duty with such brigades and divisions of the troops of the Signal Corps, including the Aviation Section thereof, as may be organized by the President.

Vacancies in all grades of the Regular Army, National Army, or National Guard resulting from the temporary

appointment of officers thereof to higher grades shall be filled or vacated as provided for in sections eight and nine of the Act authorizing the President to increase temporarily the military establishment of the United States and approved May eighteen, nineteen hundred and seventeen.

SEC. 6. That officers detailed in or attached to the Aviation Section of the Signal Corps may, when qualified therefor, be rated as junior military aviators, military aviators, junior military aeronauts, and military aeronauts, but no person shall be so rated until there shall have been issued to him a certificate to the effect that he is qualified for the rating, and no certificate shall be issued to any person until an examining board, which shall be composed of two officers of experience of the Aviation Section of the Signal Corps and one medical officer, shall have examined him under general regulations to be prescribed by the Secretary of War and published to the Army by the War Department, and shall have reported him to be qualified for the rating. No person shall receive the rating of military aviator or military aeronaut until he shall have served creditably for three years as an aviation officer with the rating of a junior military aviator or the rating of a junior military aeronaut, except that in time of war any officer or enlisted man who specially distinguishes himself in active service may, upon recommendation of the Chief Signal Officer of the Army, be rated as a junior military aviator, military aviator, junior military aeronaut, or military aeronaut without regard to examination or to length of service: *Provided,* That junior military aeronauts and military aeronauts shall be entitled to the same increase in rank and pay as are now authorized by law for junior military aviators and military aviators, respectively: *Provided further,* That any officer attached to the Aviation Section of the Signal Corps for any military duty requiring him to make regular and frequent flights shall receive an increase of twenty-five per centum of the pay of his grade and length of service under his commission.

SEC. 7. That the Secretary of War is authorized from time to time to cause such number of the enlisted men of

the Aviation Section of the Signal Corps above the grade of corporal as he may deem necessary to be rated as aviation mechanicians or as balloon mechanicians in the manner now prescribed by law: *Provided,* That balloon mechanicians shall receive the same increase of pay as now prescribed by law for aviation mechanicians.

SEC. 8. That all officers and enlisted men of the temporary forces of the Signal Corps, including the Aviation Section thereof provided for herein, shall be in all respects on the same footing as to pay, allowances, and pensions as permanent officers and enlisted men of corresponding grades and length of service in the Regular Army.

Provided, That nothing in this Act shall operate to decrease the present authorized strength of the Regular Army or National Army heretofore authorized by law.

SEC. 9. That during the existing emergency authority is hereby given to the President, through the War Department, for the purchase, manufacture, maintenance, repair, and operation of airships and other aerial machines, including instruments and appliances of every sort and description necessary for the operation, construction, or equipment of all types of aircraft, including guns, armament, ammunition, and all necessary spare parts, and equipment connected therewith; and all necessary buildings for equipment and personnel in the Aviation Section and for the purchase, maintenance, repair, and operation, through the Chief Signal Officer of the Army, of all motor-propelled passenger and equipment carrying vehicles which may be necessary for the Aviation Section of the Signal Corps.

And during the existing emergency authority is hereby further given for the establishment, equipment, maintenance, and operation of aviation stations, including (a) the acquisition of land, or any interest in land, with any buildings and improvements thereon, by purchase, lease, donation, condemnation, or otherwise: *Provided,* That by order of the President any unappropriated or reserved public lands may be reserved from entry, designated, and used for such aviation stations; (b) the improvement of such land by clearing, grading, draining, seeding, and otherwise mak-

ing the same suitable for the purpose intended; (c) the construction, maintenance, and repair of permanent or temporary barracks, quarters, hospitals, mess houses, administration, instructional and recreational buildings, hangars, magazines, storehouses, sheds, shops, garages, boathouses, docks, radio stations, laboratories, observation stations, and all other buildings and structures necessary or advisable; (d) procuring and introducing water, electric light and power, telephones, telegraph, and sewerage to aviation stations and buildings and structures thereon by the extension of existing systems or the creation of new systems and their maintenance, operation and repair, installation of plumbing, electric fixtures and telephones, fire apparatus and fire alarm systems and the maintenance, operation and repair of all such systems, fixtures and apparatus; (e) construction and repair of roads, walks, sea walls, breakwaters, bridges, and wharves, dredging, filling and otherwise improving land and water sites; (f) purchase of stoves and other cooking and heating apparatus, kitchen and tableware, and furniture and equipment for kitchens, mess halls, offices, quarters, barracks, hospitals, and other buildings, screens, lockers, refrigerators, and all other necessary equipment; (g) purchase of gasoline, oil, fuel, and all supplies of every kind and character necessary or advisable for maintenance and operation of aviation stations, including electric light and power, telephones, water supply and sewerage service; (h) purchase and manufacture and installation of all kinds of machinery, tools, material, supplies, and equipment for construction, maintenance, and repair of aircraft, buildings, and improvements at aviation stations, or property or appliances used in connection with aviation.

And also for the purchase or manufacture and issue of special clothing, wearing apparel, and similar equipment for aviation purposes.

And also for the actual and necessary expenses of officers, enlisted men, and civilian employees of the Army and authorized agents sent on special duty at home and abroad for aviation purposes, including observation and investigation

of foreign military operations and organization, manufacture of aircraft, and engines, also special courses in foreign aviation schools and manufacturing establishments, to be paid upon certificates of the Secretary of War certifying that the expenditures were necessary for military purposes.

And also for vocational training, including employment of necessary civilian instructors in important trades related to aviation, purchase of tools, equipment, materials, and machines required for such training, purchase of textbooks, books of reference, scientific and professional papers, periodicals and magazines, and instruments and material for theoretical and practical instruction at aviation schools and stations, and all other means to carry out the provisions of section twenty-seven of the Act approved June third, nineteen hundred and sixteen, authorizing, in addition to the military training of soldiers while in active service, means for securing educational and vocational training of a character to increase their military efficiency and enable them to return to civil life better equipped for industrial, commercial, and general business occupations.

And also to pay and otherwise provide for such officers of the Officers' Reserve Corps of the Aviation Section of the Signal Corps and such enlisted men of the Enlisted Reserve Corps of the Aviation Section of the Signal Corps as may be called into active service and such enlisted men as may be enlisted in the Aviation Section of the Signal Corps under the provisions of section two of the Act to increase temporarily the military establishment of the United States, approved May eighteenth, nineteen hundred and seventeen, or any subsequent Act temporarily increasing the commissioned or enlisted personnel of the Aviation Section of the Signal Corps and such civilian employees as may be necessary, for the payment of their traveling and other necessary expenses when not traveling with troops: *Provided,* That hereafter all reserve officers and enlisted men of the Aviation Section of the Signal Corps shall be paid by Quartermaster Corps disbursing officers from funds transferred to their credit from Signal Corps appropriations.

And also for the payment of all expenses in connection with the development of suitable types of aviation engines,

airplanes, and other aircraft appurtenances, including the cost of sample engines, airplanes, and appurtenances, cost of any patents and other rights therein, and costs of investigation, experimentation, and research in respect thereto.

And also for the payment of all expenses in connection with the creation, expansion, acquisition, and development of plants, factories, and establishments for the manufacture of airplanes, aircraft, engines, and appurtenances, including provision for the purchase or lease of land with the buildings thereon, construction of permanent or temporary buildings for all purposes, purchase of machinery, tools, and employment of operatives, together with all administrative expenses necessary, the purchase and supply of raw and semifinished materials and of fuel and all other things necessary for creating and extending the production of airplanes, aircraft, engines, and all appurtenances.

And also for creating, maintaining, and operating at technical schools and colleges courses of instruction for aviation students, including cost of instruction, equipment, and supplies necessary for instruction and subsistence of students while receiving such instruction.

Provided, That, subject to the approval of the Secretary of War, motor-propelled vehicles, airplanes, engines, parts thereof, and appurtenances may be exchanged in part payment for new equipment of the same or similar character to be used for the same purpose as those proposed to be exchanged.

Provided further, That during the present emergency, officers and enlisted men in foreign armies attached to the Aviation Section of the Signal Corps as instructors or inspectors when traveling in the United States on official business pertaining to the Aviation Section of the Signal Corps shall be authorized, from funds appropriated by this Act, the same mileage and transportation allowances as are authorized for officers or enlisted men of the Regular Army.

SEC. 10. That for the purpose of carrying this Act into effect the sum of $640,000,000 is hereby appropriated out of any funds in the Treasury not otherwise appropriated, to be available until June thirtieth, nineteen hundred and eighteen.

II. Air Service Stations on November 11, 1918

Flying Fields

The special functions of the different fields are indicated as follows: *A*, advanced flying; *B*, bombing school; *F*, primary flying; *G*, aerial gunnery; *I*, instructors school; *O*, observers' school; *P*, pursuit flying; *PG*, photographic. Figures in parentheses after names of fields refer to number of auxiliary fields.

	Location	Maximum Cadet Capacity
Baker's Field: *PG*	Rochester, N. Y.	...
Barron Field (1): *F*	Everman, Tex.	300
Bolling Field: *A*	Anacostia, D. C.	...
Brooks Field (2): *I*	San Antonio, Tex.	300
Call Field (1): *O*	Wichita Falls, Tex.	300
Carlstrom Field: *P*	Arcadia, Fla.	400
Carruthers Field (1): *F*	Benbrook, Tex.	300
Chanute Field (1): *F*	Rantoul, Ill.	300
Dorr Field: *G*	Arcadia, Fla.	120
Eberts Field (1): *F*	Lonoke, Ark.	300
Ellington Field (6): *B* and *G*	Houston, Tex.	600
Emerson Field: *A*	Columbia, S. C.	...
First Reserve Wing:	Mineola, L. I., N. Y.	...
Brindley Field: *A*	Commack, L. I., N. Y.	...
Henry J. Damm Field: *A*	Babylon, L. I., N. Y.	...
Hazelhurst Field: *A*	Mineola, L. I., N. Y.	...
Lufberry Field: *A*	Wautaught, L. I., N. Y.	...
Mitchell Field: *A*	Mineola, L. I., N. Y.	...
Roosevelt Field: *A*	Mineola, L. I., N. Y.	...
France Field: *A*	Cocoa Walk, Panama Canal Zone	...
Gerstner Field: *B*	Lake Charles, La.	600
Kelly Field (2): *F*	San Antonio, Tex.	600
Love Field (2): *F*	Dallas, Tex.	300
March Field: *F*	Riverside, Cal.	300
Mather Field: *F*	Sacramento, Cal.	300
Park Field (2): *F*	Millington, Tenn.	300
Payne Field (2): *A*	West Point, Miss.	300
Post Field: *O*	Fort Sill, Okla.	315
Rich Field (5): *F*	Waco, Tex.	300
Rockwell Field (1[1]): *P* and *G*	San Diego, Cal.	400

[1] Auxiliary field at Otoymaso, Cal.

FLYING FIELDS — *Continued*

	Location	Maximum Cadet Capacity
Second Reserve Wing:	Park Place, Houston, Tex.	...
Selfridge Field: *G*	Mt. Clemens, Mich.	350
Scott Field (1): *F* and *I*	Belleville, Ill.	300
Souther Field (1): *F*	Americus, Ga.	300
Taliaferro Field: *G*	Hicks, Tex.	180
Taylor Field (3): *F*	Montgomery, Ala.	300
Camp Dick (Cadet Gunnery Camp)	Dallas, Tex.	4,500
Wilbur Wright Field (Armorers' School)	Fairfield, Ohio	600
Langley Field (Observers' School)	Hampton, Va.	210

SCHOOLS OF MILITARY AERONAUTICS

University of California	Berkeley, Cal.	1,200
Cornell University	Ithaca, N. Y.	1,000
Princeton University	Princeton, N. J.	1,200
University of Illinois	Urbana, Ill.	1,200
University of Texas	Austin, Tex.	1,400

BALLOON SCHOOLS

Army Balloon School (2)	Fort Omaha, Neb.
Army Balloon School	Lee Hall, Va.
Army Balloon School	Arcadia, Cal.
Camp John Wise	San Antonio, Tex.
Balloon Detachment	Fort Monroe, Va.
Balloon Detachment	Fort Sill, Okla.
Balloon Detachment	Langley Field, Va.
Balloon Detachment	Camp McClellan, Anniston, Ala.
Balloon Detachment	Camp Knox, Stithton, Ky.
Balloon Detachment	Camp Jackson, Columbia, S. C.

RADIO SCHOOLS

Air Service School for Radio Officers	Columbia University, New York, N. Y.	300
Air Service School for Radio Operators	Penn Field, Austin, Tex.	1,000
Air Service School for Radio Mechanics	Carnegie Institute of Technology, Pittsburgh, Pa.	1,200

Firing Centers [2]

Camp Jackson	Columbia, S. C.
Camp Doniphen	Fort Sill, Okla.
Camp McClellan	Anniston, Ala.
Camp Knox	Stithton, Ky.

Photographic Schools

		Maximum Student Capacity
U. S. School of Aerial Photography	Rochester, N. Y.	750
Photographic School, Cornell University	Ithaca, N. Y.	250
Preliminary Photographic School	Fort Ethan Allan, Burlington, Vt.	2,500

Mechanics Schools

Air Service Mechanics School	Kelly Field, South, San Antonio, Tex.	3,700
Air Service Mechanics School	Overland Building, St. Paul, Minn.	3,700

Aviation General Supply Depots

Americus, Ga.	Little Rock, Ark.
Fairfield, Ohio	Washington, D. C.
Houston, Tex.	Washington, D. C.
Middletown, Pa.	Buffalo, N. Y.
Richmond, Va.	Detroit, Mich.
San Antonio, Tex.	San Francisco, Cal.
Los Angeles, Cal.	Sacramento, Cal.

Balloon General Supply Depot

Richmond, Va.

Air Service Depots

Garden City, L. I., N. Y.	Morrison, Va.

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[2] Air Service radio officers instructing Artillery personnel at these locations.

Aviation Repair Depots

Indianapolis, Ind.
Dallas, Tex.
Montgomery, Ala.

Recruit Concentration Camps

Fort Wayne, Mich.
Kelly Field, San Antonio, Tex.

Technical Section

Air Building, Dayton, Ohio.

Testing Field

Wilbur Wright Field, Fairfield, Ohio.

Acceptance Parks

Acceptance Park, Dayton-Wright Airplane Co., Dayton, Ohio.
Acceptance Park, Fisher Body Co., Detroit, Mich.

Miscellaneous Stations

Camp Alfred Vail	Little Silver, N. J.
Chandler Field	Essington, Pa.
271st Aero Squadron	Aberdeen, Md.
6th Aero Squadron	Honolulu, H. I.
7th Aero Squadron	Panama Canal Zone

Ports of Embarkation

New York, N. Y.
Newport News, Va.
Philadelphia, Pa.
Baltimore, Md.

Department Air Service Offices

Central Department: Chicago, Ill.
Eastern Department: New York, N. Y.
Northeastern Department: Boston, Mass.
Southern Department: Fort Sam Houston, Tex.
Southeastern Department: Charleston, S. C.
Western Department: San Francisco, Cal.
Philippines Department: Manila.
Hawaiian Department: Honolulu.
Panama Canal Department

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